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More Co-operation Suggested

There is one aspect of technical co-operation which so far as we are aware has escaped the notice of the wartime organisations, and that is, the fullest utilisation of the experts employed by private enterprises. Normally the specialists engaged by manufacturing firms are so busy as to preclude any thought of additional employment. The case, however, may be quite different with concerns which have plant made for them, for in secondary industries engineers and other specialists have to be kept in reserve ready to start up the plants as they are delivered. With the best organisation possible it usually happens that either a number of plants are waiting to be started up because of the dearth of staff or the specialists are marking time or doing work of a non-specialist character because there is a lull in delivery. It is not unreasonable to imagine that a lull experienced by one firm may coincide with a period of pressure in the case of its competitors. Firms seldom think twice about borrowing materials from one another to overcome a temporary shortage, but would hesitate to suggest the temporary employment of a competitor's specialist to help to get a plant erected and started up. There usually exists too much jealousy, associated with a risk of a competitor learning too much about the details of one's plant, yet in wartime one must take risks, and in so much as the idea is reciprocal, it must be realised that although there is a tendency to "teach" the competitor, there is the countervailing fact that one must learn from them. The final outcome would be that any section of any industry envisaging such a scheme would, in the long run, be materially strengthening the technical position of the trade. What actually happens is that when this class of firm gets busy, they advertise for specialists and engage a man from their competitor's staff, and so merely transfer the shortage, just as the belligerents buy up material to prevent it being consigned to the enemy. Firms in competition in wartime are not enemies but allies, and they can usefully follow the example of the French and British Governments by intense co-operation. The joint utilisation of the specialists available to a section of an industry is one of the best forms of co-operation. We write with a full knowledge of this phase, as during the last war non-co-operation reduced our personal efficiency by about 25 per cent. The position then was that a batch of four or more furnaces was all ready for starting up by a staff of two metallurgists, and obviously some had to wait two or more months. This work having been accomplished, there was an interval of maybe a month waiting for the delivery of a further batch. The firm with which we were then associated had three competitors, and conversations with their metallurgists revealed an exactly parallel state of affairs. We cannot imagine that conditions have so changed in these very important "secondary" industries that the "humps and hollows" have straightened out themselves. As a wartime measure, therefore, we suggest that the firms engaged in these secondary industries should, when requiring additional specialists, first consult their competitors and disclose to them the periods of excessive pressure and relative quietness. By the better utilisation of this outdoor staff it may be that much travelling and time and expense could be saved. For example, during the last war, we had no sooner finished the starting up of a plant at Bilbao, when a well-known specialist from a competitive concern arrived at Santander to install a similar, but larger, plant. Considering the delay in wartime due to obtaining passports and visas, a saving of a full fortnight could be ascribed to this phase alone. Again, trouble arose on more than one occasion, through specialists being taken from one job before it was finished because the directorate wished to satisfy a second concern that they really were making an effort to "get their new plant away." From the above, much of which is drawn from personal experience, there does seem to be a good case for the private pooling of the "outside" technical resources of the secondary industries.

At the moment, there is a growing tendency for the light castings concerns to receive orders for engineering components, and here again there is a case for technical co-operation. The foundry industry is so widespread that in most cases both engineering and light castings foundries exist quite near to one another. Generally speaking, the former can help, either on the practical side or through their metallurgical control organisation, and wherever possible this help should be asked for and given. The competitive aspect can be forgotten, for as soon as hostilities cease, the light castings foundries will return to the meeting of the builders' merchants' requirements. Such co-operation is far preferable to central control, and its full prosecution will do much to render Government interference unnecessary. If problems cannot be solved locally, then recourse can be had to the research organisations, either connected with industry or attached to the great national raw material concerns, such as nickel, copper, aluminium and so forth.

Book Reviews

Ryland's Directory, 1940 (25th edition). Published by "The Iron and Coal Trades Review," 49, Wellington Street, London, W.C.2. Price, bound in cloth, £2 2s.; bound in leather, £2 12s.

The reviewer would first offer his congratulations to the publishers on having attained their golden jubilee. The Directory's character, like the industries it covers, has changed, whilst its expansion has been tenfold. The present make-up has long been established, and its worth has been thoroughly tested, receiving the full approbation of users. It must not be thought that it is static, as new lists are introduced which the changing conditions of industry demand. For instance, the complete lists of Dominion foundries are now a regular feature. Similarly, a list of high-duty ironfounders has been included.

A perusal of the list of electric furnaces used by the steel industry emphasises the necessity of extending this to include those used for melting cast-iron, as there is a strong tendency for this practice to increase, and borderline cases abound. Simultaneously, there is the tendency for the rotary furnaces, developed for melting iron, to be used for steelmaking. On these grounds the extension of the present list and the creation of a new one are suggested as future additions.

The number of iron foundries seems to be much the same as in the last edition, a little over 66 columns being taken up by their listing. The steel foundry industry is tending to grow and several new names appear. This is perhaps a narrow way of evaluating the potentialities of Ryland's, for its major use to foundry owners could be tabulated along the following lines: (1) the disclosure of the field for the sales of any particular line of casting, such as, for instance, the railway companies of the world, collieries, coke ovens, electric power stations, and the various types of engineers, such as machine tool builders and so forth; (2) the rapid finding of telegraphic addresses; (3) the general standing of companies as given by their capital and composition of the directorate; (4) the numbers and types of works in any town or county, and (5) where to buy the raw materials of the industry. This last factor is of major importance at the present time, when the character of the output of various industries is likely to change.

The reviewer was particular pleased to receive a copy of the new edition, as he had to sacrifice his personal 1938 copy, and share one with his colleagues, because of an urgent request by a very important Government department, which could not very well be refused. This does show how valuable Ryland's is when crises occur and industrial information must become easily available.

Industrial Law. By H. Samuels, M.A., second edition. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 15s. net.

The first edition of this book, which received general commendation, was published before the passing into law of the Factories Act in 1937. This measure has had such a profound influence on industrial law that a 2nd edition of the book became imperative. The recent emergency enactments have had equally important reactions, and space, by way of an appendix has been found for their analyses.

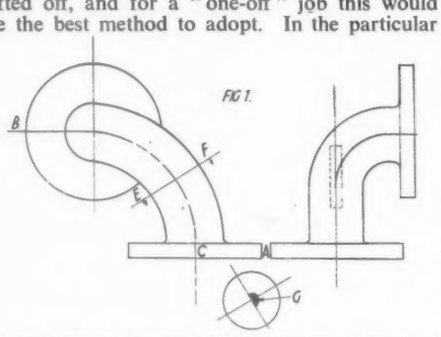
The type of matter covered by the book can best be shown by citing the headings of the chapters, which, taken seriatim, read: The Law Concerning Apprenticeship; Contract of Employment; Statute Law Concerning Wages; Statute Law Concerning Conditions of Work in Factories; the Law Relating to Mines; Employers' Liability for Accidents; the Law Concerning Trade Unions and Trade Associations; National Insurance of Employees; the Law Concerning Schemes of Co-operation and Voluntary Welfare; and Conciliation and the Settlement of Disputes.

One feature of this book which the layman will appreciate is adequate punctuation (except in the case of some quotations), a factor missing from so many legal textbooks. Clarity of expression, associated with ease of assimilation by the reader, also makes the book noteworthy.

A Novel Dowel

BY "FOUNDRYMAN."

Although the insertion of either an iron plate or a brass plug and socket dowels is a simple matter, the question of the dowelling of the two halves of a pattern sometimes arises and cannot be so easily disposed of. Particularly is this true when the pattern cannot be jointed through the horizontal plane but has to follow the centreline of the required casting. Such a case is illustrated in Fig. 1, which shows a double turn pipe. Joints in the mould have to be taken at A and B, following the centreline B C. This pattern could be made solid and the top-half lifted off, and for a "one-off" job this would be the best method to adopt. In the particular



case under review, several castings were required and a jointed pattern would make for a cleaner mould and would be easier to ram up, especially if a joint board was supplied. As can be seen, the insertion of orthodox dowels was out of the question and the difficulty was surmounted by securing a fairly long tongue to one half of the pattern. This tongue followed the contour of the joint and in the other direction had a generous taper imparted to it. A suitable recess cut in the other half of the pattern ensured correct location, the taper allowing the top to be easily lifted without tearing down the sand. The dotted lines in Fig. 1 illustrate this novel dowel, while a section of the pattern through E F is shown at G.

Demolition of the "Mauretania"

Last Friday, members of the Manchester Association of Engineers listened with much interest to a Paper on this subject by MR. M. WILKINSON, B.Sc. It is clear from a study of his lecture that the breaking-up of ships of such large tonnage as the "Mauretania" is an engineering feat of no mean character. After dealing with the establishment of constants for estimating the price to be paid for the vessel, information is given as to the utilisation of these constants in practice.

After detailing the classification of both ferrous and non-ferrous scrap, and the non-metallic materials, the author points out that the only stuff wasted is concrete filling and rubbish consisting of broken tiling and composition decks. The procedure of demolition as described is particularly interesting. For instance, the paint on the funnels was $\frac{3}{8}$ in. thick, and the quantity of lead incorporated necessitated the use of gas masks by the operatives employed on cutting them by means of the oxygen blowpipe. A useful figure disclosed is the oxygen consumption per ton of metal, which is of the order of 350 cub. ft., associated with an output of 6 to 8 tons per day per man.

Random Shots

It is a strange fact that when talking of the changes that occur with the passage of time, everyone should unanimously use the phrase "the world's progress." That there is continued change is indisputable, but whether or not that change constitutes progress is a very debatable point. A recent report, for instance, states that tunnels made by Boulton at the Soho Foundry a century and a half ago are now being used as air raid shelters! Progress indeed! Another report says that the narrow gauge railway which used to function between Halesworth and Southwold in Suffolk is to be pulled up for scrap, presumably for armaments. Anyone who has ever raced that comic Puffing Billy in his low-powered car cannot help feeling sorry that the last traces of it are to disappear, and so with it, perhaps, all memories of those pleasantly quiet and peaceful far-off days. It always was a joke, that railway, as can be seen by the picture postcards in any of the local shops, but it was a good joke because it led its passengers gently to one of the most charming spots in the land. Nowadays a modern motor coach runs down to Southwold. Looking farther ahead, that very bus itself may yet become the home of some retired English gentleman impoverished beyond all hope by the very machinations of modern progress!

* * *

Incidentally, talking of retired English gentlemen, anyone who thinks he is at the "sunset of his life" after he has reached the allotted "three score years and ten" will receive fresh impetus and inspiration by remembering that Mr. Chamberlain celebrated his 71st birthday last Monday.

* * *

Last Sunday was a "red-letter day" for Irishmen, who always make St. Patrick's Day an excuse for demonstrating in practical manner their natural light-heartedness. All "Mickies" engaged in the foundry industry will be interested to learn that not only is St. Patrick supposed to have rid Ireland of snakes, but that he associated himself with the bellfounders of his day. According to Mrs. Frazer, who read a Paper before the Old Dublin Society on the old bells of Dublin, St. Patrick interested himself especially in the work of three bellsmiths who, evidently blessed by the patronage of this holy man, became skilled metal workers.

* * *

A new and interesting feature of the radio is the weekly talk by "Onlooker." Here the "F.T.J." scores again as being a progressive paper, for another "Onlooker" has been contributing regularly in the journal for many months!

* * *

This issue welcomes its readers on the eve of the Easter holiday. Let us all hope for fine sunny days so that those tired workers suffering from "internal stresses" will be able to get outside and "dig for victory." Some, of course, will probably feel too tired even to dig at all, and they will look forward to spending a really lazy week-end. Like the woman who had raised a family of ten and worked hard all her life, whose epitaph read

"Don't weep for me now,
Don't weep for me never,
I'm going to do nothing
For ever and ever,"

they can think of nothing more delicious than to follow her advice. Good luck! And let it be hoped that the Auxiliary Fire Service doesn't practise outside those drawn curtains!

"MARKSMAN."

Stress-Relieved Cast Irons*

By A. Le THOMAS

In recent months, the question of the supply of castings in stress-free iron for use in the machine-tool trade has been well to the fore-front. The records of the French foundry research association, the best barometer of the technical preoccupations of the foundry industry of that country, show a sustained interest in this subject. Despite the fact that the author has previously dealt with the subject,† it appears desirable to recapitulate in some detail the principal points because of the present importance of the subject and because of the mistakes and misunderstandings which have come to light in certain cases. It has been put forward by some interested parties that stress-free iron is the product of a new and secret process, it never having been the subject of any Paper in technical literature. The list of the author's own work set out at the foot of this column shows how ill-founded this statement is.

What is Stress-Relieved Iron?

Many foundrymen and engineers have on the other hand been the victims of confusion, possibly of an homonymy. The expression "stress-relieved iron" admits of two different inter-

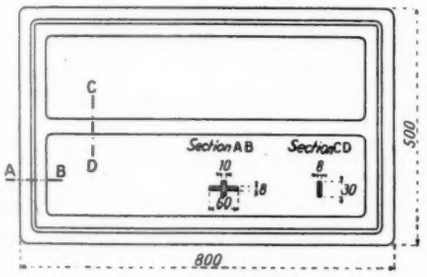


Fig. 1.—A Ribbed Casting Exhibiting Every Likelihood of Carrying Internal Stresses.

pretations. It can refer, as is here envisaged, to the effect of a treatment following upon casting and designed to eliminate internal stresses or tensions which can deform or even fracture the casting during the course of its completion or in service; but it can also be understood as relating to an iron with its composition so controlled that the carbide Fe_3C is in such a condition that it confers high stability during repeated reheating—in other words, an iron having a very high "graphitisation temperature," which is usually obtained, as is well known, by the addition of certain special elements. A mistake frequently encountered, and one which can have disastrous results for the foundryman, is that stress-free cast irons so insistently asked for by machine-tool makers are just chromium-bearing irons of the heat-resisting type. Finally, certain foundrymen have been known to translate—by some complex mental process—the expression "stress-free cast iron" as nickel cast iron.

A good definition of irons currently designated by the qualification "stress free" can be found in the official specifications, which in addition serve as a model for most of the official documents relating to the acceptation conditions of iron castings for machine assemblies. The two following paragraphs extracted from the French Admiralty specifications illustrate the point:—

"*Manufacture.*—The supplier is free as to the choice of the methods of moulding and casting. In this choice, he should invariably be guided by the object of avoiding, as far as possible, the existence of internal stresses in the castings at the time of delivery."

"*Treatment.*—In order the better to ensure the elimination of these stresses, but only if the bid specifically states it, a stress-relieving treatment will be undertaken. This treatment will include a prolonged heating to a temperature of the order of 500 deg. C., but lower than 625 deg. C., followed by extremely slow cooling. The total duration will be from 24 to 48 hrs. No other method of treatment will be permitted."

Cause of Internal Stresses

It may be interesting to ask "Why?" iron castings, on stripping from the moulds into which they have been cast, are nearly always affected by internal stresses. These forces, which can sometimes be sufficiently powerful to bring about apparently spontaneous rupture, result from contractional differences, to which the various members of the same casting are subjected. The so-called inequalities of contraction are due to:

(1) Differences in temperature encountered during the cooling of the mould at any given time at different points of the casting, such as areas near to the runner, which are hotter than those well removed therefrom; moreover, thin walls cool faster than massive ones, and so on.

(2) The law of contraction in a casting for an iron of any given composition is not the same, according as the cooling is slow or rapid; an iron cast in a thin section contracts more than when it is cast into a massive block.

The author has given on various occasions (*loc. cit.*) explanations of these phenomena, and reference should be made to them by those desiring complete information. In this article, which is strictly practical and is free from all matter not definitely indispensable, the study has been limited to detailing the nature and stressing the importance of those internal stresses which affect raw castings.

How a Frame Casting Contracts

Supposing, to take an extreme case, the frame casting shown in Fig. 1 had to be made. The contour is ribbed and a relatively thin bar traverses the casting across its wider part. Every technician knows that it is very difficult, if not impossible, to obtain a casting conforming to this design. The transversal bar will generally be cracked (usually at one of the ends), and it will readily be appreciated how the observations cited earlier—inequalities of rate of cooling and contraction—apply in this case.

Warped Castings

This example can readily be used for generalisations, and its lessons can be extended to take in numerous iron castings which show great rigidity of design, so opposing contraction to the point of rupture of their members. All foundrymen have encountered this class of work, which has fractured without apparent reason, either during stripping or fettling or even on the delivery van. Two-armed or webbed pulleys, socles or components for machine tools of a box-like character showing excessive rigidity, etc., are typical of such castings. More frequently, and perhaps more fortunately, are the cases where the castings, without showing cracks, are somewhat out of shape, usually manifesting this phenomenon during machining, especially at the time of skin removal. If internal stresses are an ever-present danger, then the search must be for their elimination and stress-relieving heat-treatment suggests itself.

Occurrence in Other Industries

It is germane to point out that iron castings are not the only industrial materials which are subject to internal stresses, and from this fact warrant a stress-relieving treatment. Most people have encountered this curious phenomenon in the case of glass tumblers, which have shattered when left alone on a table and have not received any shock. Glassware is submitted at the termination of the manufacturing processes to annealing in a special furnace, but it should be realised that this treatment has

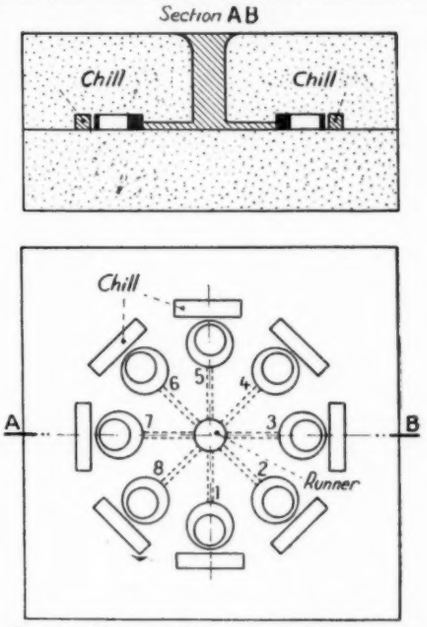


Fig. 2.—Method Used for Casting Eccentric Ring Test-Pieces.

not been adequate when auto-fracture occurs.

Many engineers have also experienced deformations in the case of steel forgings during machining, especially in the case of propeller shafts (in marine engineering these shafts are frequently 23 to 27 ft. long and the deflections showing up after skin-machining are particularly pronounced). This warping in precision marine engineering is avoided by submitting the forgings to a stress-relieving treatment carried out at about 350 to 400 deg. C. This removes not only the internal stresses but also the deformations consequent thereon.

Many experienced men have referred to auto-breakages of round or hexagonal extruded brass sections in the stores. This is a further example of internal stresses, assuming in this case a particularly complex aspect, but still admitting of the same type of cure.

A Hypothetical Example

These examples could be multiplied, and returning to the case of cast iron it may be as well to point out that it is quite easy to obtain some idea of the forces set in motion when they oppose contraction. First of all, try to imagine the quite theoretical case of a ruler cast in ordinary iron a metre long, and having attained the temperature of 520 deg. C. its ends are attached by its two extremities to indeformable masses and then allowed to cool to room temperature (say 20 deg. C.). As the temperature decreases, the ruler tends to contract, but as its two ends are rigidly fixed, things happen just as if the two ends were subject to an increasing tensile strain, sufficient to set up an elongation exactly compensating the contraction. The

D

* Translated from "La Fonte."

† "La Suppression des Tensions Internes dans les Pieces en Fonte Mecanique," C.R. Ac. Sci., vol. 185, p. 1134 (1927). "Sur les Tensions Internes," Bull. de l'Assoc. Tech. Fond., Oct., 1928, p. 299. "Les Traitments de Stabilisation et de Graphitisation des Fontes," "La Fonte," July, Aug. and Sept., 1931, p. 17. "Les Traitments Thermiques des Fontes," "La Fonderie Belge," Sept., 1931, p. 10.

following calculation of this elongation at the moment when the ruler has reached room temperature can be made by taking into account that the coefficient of expansion of cast iron is 11.5×10^{-6}:—

$1{,}000 \times (11.5 \times 10^{-6}) \times 500 = 5.75$ mm.

It is now easy to evaluate the order of the magnitude of this tensile strain F (in kgs. per sq. mm.) imposed upon the ruler. It is only necessary to apply (though not strictly correct) the classical formula for the strength of materials relative to elastic elongations induced by tensile strain, taking 8,000 kgs. per sq. mm. as the value of the modulus of elasticity of ordinary cast iron:—

$$\frac{5{\cdot}75 \text{ (mm.)}}{1{,}000 \text{ (mm.) } (circa)} = \frac{1}{8{,}000} \times \frac{F}{1 \text{ (mm.}^2\text{)}}$$

This gives F = 46 kgs. per sq. mm. The ruler could not support such a stress as the iron is insufficiently strong and it would break during cooling.

It may be interesting to point out, in passing, that the stronger the iron, the greater the tendency to break due to inverse contraction. This

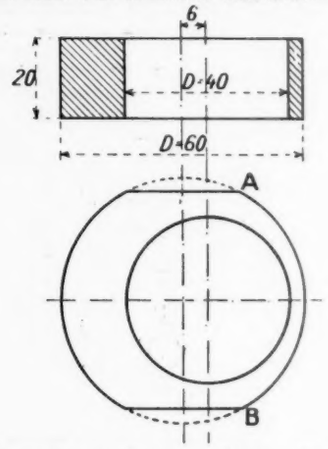


Fig. 3.—Before Sawing a Gap the Faces A and B are Machined Parallel and are Polished.

comes about because the strongest irons are those possessing the highest modulus of elasticity and the highest contraction, so that the forces coming into play through contraction are greater than the inherent strength of the iron. Moreover, it is well known that strong, close-grained irons have a more pronounced tendency to crack on contracting than have the soft, mechanically-weaker irons of which the modulus of elasticity is low and which exhibit less contraction.

The above calculation is based on an extravagant hypothesis, the two ends of the ruler being considered as rigidly fixed in space. In a casting, such as a ribbed frame to which reference has already been made (Fig. 1), the long member can be likened to the ruler, but it will not generally be subjected to so great a stress, as the ends will combine in the overall contraction of the casting. It is only the differences in the contraction which will set up internal stresses. It is obviously necessary, however, to take into consideration the increased intensity of stresses at certain positions, due to the hazards of shape (holes, notches, quick changes in section, etc.). It is quite easy to realise how the internal stresses can be sufficiently localised to cause the fracture of the iron casting, or at least add to the stresses set up during use, to help to deform it.

Practical Evaluation Considered

It would be interesting to be able to calculate or measure, by a suitable experimental method, the internal stresses which effect an iron casting. This unfortunately is impossible in most cases. Calculation is impracticable not only on account of lack of knowledge as to where one could find details of the thermal conditions causing the elementary forces due to contraction set up by the cooling in the mould, but also because the analysis of the separation of the forces in a more or less complicated casting is beyond one's mathematical faculties.

The experimental measurement of internal stresses is itself also practically impossible. One can only assess internal stresses by their results, as for example the fracture of a casting, or again in the case of eccentric rings (to be referred to later) by the deformation which they show if one modifies by notching their normal equilibrium. A reliable and well-established method is available for measuring internal stresses set up in a solid body by external means, and one need only refer to glass models examined under polarised light, as an experimental method often used in the study of bridges and other constructions. This method cannot be usefully applied to the case under consideration.

Suggested Solution

How then can one eliminate these unmeasurable internal stresses, which are so dangerous because of unforeseen fractures that they cause, or which are, at the least, annoying because of the deformations they can set up? The solution is a heat-treatment based upon the following observations. It has long been known that if a casting is slowly heated, without necessarily being made red hot, and is allowed to cool slowly, it no longer gives cause for anxiety on account of either fracture or deformation of the types being dealt with. It is also well known that the same result is brought about by weathering for six months or a year in the open air. It is intended to throw additional light or create a better definition of these processes, although this has already been done,* by detailing once again the experiments made.

Experimental Method

The test-piece chosen for the experiments was an eccentric ring cast in pearlitic iron of high strength, the inside and outside diameters of which were 40 and 60 mm. respectively. The centres were out of truth by 6 mm., and the depth of test-pieces was 20 mm.

Several test-pieces were made concentrically and simultaneously in the same mould, so as to obtain perfect homogeneity of metal in the same test-series. To intensify the internal stresses, the thin section of the test-piece was placed near the chill, as is shown in Fig. 2.

After casting, the samples were stripped. One was machined on the outside as shown in Fig. 3, and the thick section was saw-cut. The test-piece then opens slightly under the effect of internal stress and the order of its magnitude is measured. The differences (set out in Fig. 3) so revealed, characterise the order of the importance of the internal stresses existing in the thin section. One as-cast and four heat-treated test-pieces were submitted to this treatment, the temperatures being 300, 400, 500 and 600 deg. C. In every case the duration of the treatment was about one hour at the desired temperature followed by a further ½ hour for cooling, in order to avoid the creation of fresh stresses. The heat-treatment being carried out, the test-pieces were machined as shown in Fig. 3. Table I and Fig. 4 set out the results of these measurements as well as the shear strength and the Brinell hardness, which are little affected by the heat-treatment.

* "Les Traitments de Stabilisation et Graphitisation des Fontes," "La Fonte," July, Aug. and Sept., 1931, p. 17.

Results Analysed

It is obvious that the affect of reheating begins to make itself felt at about 300 deg. C., and the dispersal of internal stresses is virtually accomplished at 600 deg. C. To make this sure, it should be sufficient slowly to heat castings up to about 650 deg. C., allowing them to cool slowly. The tensile strength of cast iron is somewhat lowered by this treatment. The changes have been followed micrographically by the author and they are: Up to 500 deg. C. there is no apparent change, beyond a tendency for the pearlite to coalesce; at 600 deg. C. there is the formation of free graphite with a deposition of temper carbon.

It is interesting to note that a ring which has not been heated but lightly ground on the inside, with water cooling, only opens after sawing through by a third of the amount shown in the as-cast sample. This indicates that the elimination of the skin of the casting is sufficient considerably to reduce the internal stresses; there is every appearance of these being located on the surface. In the tests described above the application of another method of eliminating the as-cast skin by plunging the castings into a slightly acid solution, or merely by weathering, has not been attempted. Other tests, however, have indicated that the results would be the same in so far as they relate to the relief or elimination of internal stresses, providing that the quantity of material removed from the surface be sufficient.

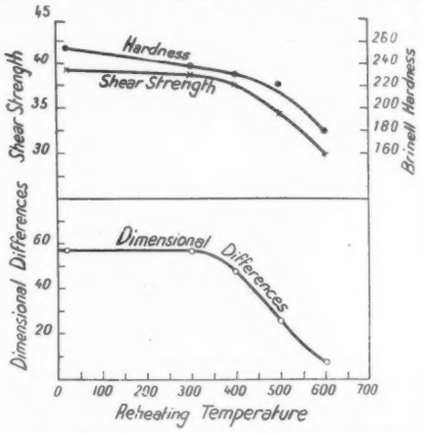


Fig. 4.—Influence of Heat-Treatment on the Properties of the Ring.

Table I.—*Magnitude of Internal Stresses as Affected by Heat-Treatment.*

Sample no.	Condition.	Width. Mm.		Difference in width. Mm.	Shear strength. Kgs. per sq. mm.	Brinell hardness.
		Before sawing.	After sawing.			
1 ..	As cast	54.142	54.200	0.058	39.25	255
	Heated to—					
2 ..	300 deg. C.	55.045	55.102	0.057	38.70	235
3 ..	400 ,,	54.946	54.994	0.048	37.10	228
4 ..	500 ,,	55.000	55.026	0.026	34.40	220
5 ..	600 ,,	54.972	54.978	0.006	29.90	178

Practical Application

The research detailed above provides ample data for practical stress-relief of iron castings. A reheating reaching the maximum temperature of 600 to 650 deg. C., slowly carried out as to both heating and cooling, eliminates with certainty the inherent internal stresses. From this aspect the relative clauses of the (French) Admiralty Specification are justified and merit even wider application.

(*Continued on page* 232.)

Melting Operations in the Non-Ferrous Foundry*

By FRANK HUDSON

The non-ferrous foundry has many immediate problems, more so perhaps than iron and steel foundries. Every engineering project is developed from a casting of one kind or another and production, particularly of copper-base cast articles, constituted the first metallurgical development that the world has ever known. Accordingly, the uninitiated might anticipate that brass foundries and ingot casting shops are model exponents and possibly originators of works metallurgy. Indirectly the last thought may be true, and if one undertook to trace the first application of works metallurgy it might conceivably be found to originate from a dispute, shall we say, about an unsatisfactory article.

So far as the direct application of metallurgy is concerned, the brassfounder, with few exceptions, has shown little initiative. There is some excuse for this as the very antiquity of the art promotes habits and methods unreceptive to modern developments, and it is not unusual to find that the whole fabric of bronze and gunmetal casting production has been built upon rule of thumb methods without the presence of guiding fundamental facts. Such a state of affairs is, of course, entirely wrong, and to-day, more than ever before, there is profitable scope and application for research of a practical nature.

For many years the practical man has been, and in some cases still is, labouring under entirely erroneous ideas as to how metals should be melted. Until quite recently it was considered satisfactory practice to employ neutral or slightly reducing furnace atmospheres using charcoal as a cover. Following investigation into the effect of gases on copper and degasification methods it is now known that such practices are incorrect and that the best results are obtained with oxidising conditions—a complete reversal of the old ideas. It is also now appreciated that the composition and condition of the metal being melted, in conjunction with alloying technique, bear an important relation to thermal reactions.

Practical application of these discoveries has led to pronounced improvement of casting quality in a wide variety of alloys, both as regards density and mechanical properties. They have exploded the theory widely held amongst practical men that virgin metal heats, say of 88:10:2 gunmetal, give inferior results to the use of remelted metal such as ingots. They provide information as to why various brands of copper behaved differently when used for alloy production in the foundry, particularly so far as sand castings are concerned, and indicate means by which these differences may be corrected—a most important point at the present time.

During the past two years it has been the privilege of the author to come in close contact with many brassfounders, large and small, antiquated and modern, throughout the length and breadth of the British Isles, and it would appear that more efficient results would undoubtedly be obtained if melting operations, in the full sense of the term, were better understood. In the first place, it might be mentioned that it is not essential to rely upon furnace control to promote oxidising conditions, as suitable treatment can be given even in the presence of reducing atmospheres. Furthermore, the degree of oxidation required is not such as to cause abnormal metal loss. It would simplify the problem to compare the melting operations entailed in connection with, say, three groups of alloys, brass, gunmetal and the true copper-tin alloys such as the 90:10 alloys and phosphor bronze, etc., and it is proposed to adopt such a course in this Paper, keeping all remarks as simple and practical as possible so that they may be the more readily understood.

TABLE I.—*Vapour Pressure of Zinc in the Industrial Brasses.**

Composition.	Partial pressure of zinc vapour at various temperatures.				
	Melting point (liquidus).		Approximate casting temperature.		Boiling point. Deg. C. (Vapour pressure Zn 760 mm.)
	Temp. Deg. C.	Vapour pressure. Mm. Hg.	Temp. Deg. C.	Vapour pressure.	
Zinc	419.5	0.139	500	1.27	918
60:40	900	160	1,040	600	1,070
65:35	930	170	1,070	595	1,100
70:30	955	150	1,100	540	1,145
80:20	1,010	85	1,150	265	1,300
90:10 .. .. (estimated values)	1,055	20	1,200	80	1,600

* "The Casting of Brass Ingots," by Genders and Bailey, Research Monograph No. 3, British Non-Ferrous Metals Research Association.

Brass Melting

There is no doubt that hydrogen is the gas which causes most trouble in melting operations, and the first point which the foundryman should bear in mind is that the solubility of hydrogen varies with different metals. For example, the affinity of zinc-free bronze for this gas is infinitely greater than, say, 70:30 brass. It is now known, in fact, that 70:30 brass is relatively immune to hydrogen unsoundness. Genders and Bailey have shown in their book, "The Casting of Brass Ingots"* a standard work of reference on the subject, that the soundness of sand-cast 70:30 brass melted in an atmosphere of hydrogen was unaffected, whilst a 5 per cent. tin-bronze treated under similar conditions showed 150 per cent. increase in porosity. It is surmised that the factor responsible for this exceptional behaviour of brass can be attributed to the high vapour pressure of the molten alloy as shown in Table I.

It is well known that liquids under certain conditions tend to give off vapour, and this process of transformation is called evaporation. At constant temperature the space above the liquid contains a definite amount of the vapour of that liquid, and this exerts a pressure known as the vapour pressure. Liquids which readily evaporate give high vapour pressures; for example, ether at 20 deg. C. has a vapour pressure of 442.2 mm. of mercury, whilst water at the same temperature has a value of 17.41 mm. Molten copper at 1,320 deg. C. has a vapour pressure of only 0.001 mm. of mercury. Vapour pressure increases with rise of temperature and a liquid boils when its temperature is such that its vapour pressure equals the pressure of the atmosphere, namely, 760 mm. of mercury. The solubility of gas in a liquid, providing it does not react chemically with that liquid, decreases with increasing vapour pressure of the liquid, becoming zero at the boiling point. Water contains air and if one watches the effect of heat on water in a glass vessel, this air can be observed coming out, long before boiling point is reached, and it is all expelled on boiling, and, so long as the water is boiling, no air can be re-dissolved.

A similar analogy exists in connection with molten metals. As the vapour pressure rises the solubility of gas becomes increasingly less until a value of 760 mm. of mercury is reached, when the liquid boils and gas is all expelled. In Table I it will be observed that the addition of zinc to copper increases the vapour pressure, and alloys containing not less than 20 per cent. zinc have boiling points well within temperature ranges arising in normal foundry practice. For example, 70:30 brass boils, *i.e.*, its vapour pressure equals 760 mm. of mercury, at 1,145 deg. C. As a matter of interest, it might also be mentioned that the boiling point of liquids is reduced as the atmospheric pressure decreases.

(*Continued on page* 228.)

TABLE II.—*Zinc Loss of* 70 : 30 *Brass under Reducing, Neutral and Oxidising Surface Atmospheres.**

Alloy.	Treatment.	Loss. Per cent.
70 · 30 brass	800 deg. in air	0.25
	1,050 deg. in air	1.7
	1,050 deg. in nitrogen (+ 2 per cent. oxygen) ..	4.7
	1,050 deg. in hydrogen	12.6
Aluminium brass (0.2 per cent. Al)	800 deg. in air	0.27
	1,050 deg. in air	0.92
	1,050 deg. in nitrogen (+ 2 per cent. oxygen) ..	2.52
	1,050 deg. in hydrogen with flux	13.8
Aluminium brass (2.5 per cent. Al)	800 deg. in air	0.003
	1,050 deg. in air	0.007
	1,050 deg. in nitrogen (+ 2 per cent. oxygen) ..	0.071
	1,050 deg. in hydrogen	15.3
Silicon brass (2.0 per cent. Si)	800 deg. in air	0.12
	1,050 deg. in air	0.67
	1,050 deg. in nitrogen (+ 2 per cent. oxygen) ..	6.0
	1,050 deg. in hydrogen	12.8
Phosphorus brass (0.05 per cent. P)	800 deg. in air	0.36
	1,050 deg. in air	15.1
	1,050 deg. in hydrogen	16.4

* "The Casting of Brass Ingots," by Genders and Bailey, Research Monograph No. 3, British Non-Ferrous Metals Research Association.

* Paper read before a joint meeting of the Lancashire Branch of the Institute of British Foundrymen and the Manchester Metallurgical Society, Mr. A. L. Key presiding.

* Research Monograph No. 3. British Non-Ferrous Metals Research Association.

Operation of Gas Producers

By F. J. MATTHEWS, B.Sc.

Efficient gas-producer operation is a subject of special importance at the present time. The operation of furnaces is greatly affected by the quality of the gas made, a poor gas reducing the rate of heat transference as well as the output of the furnaces, in addition to increased fuel consumption involved. In some cases, difficulties may arise if the best quality of producer-gas coal is not available in the district, and recourse is had to local fuels whose character in respect of ash fusibility, etc., is not so suitable for producer operation. These considerations call for careful control, so that some notes on certain features tending to the production of poor gas may therefore be timely.

The main reactions which take place in the fuel bed of the producer are set out in Fig. 1, and may be considered in relation to various

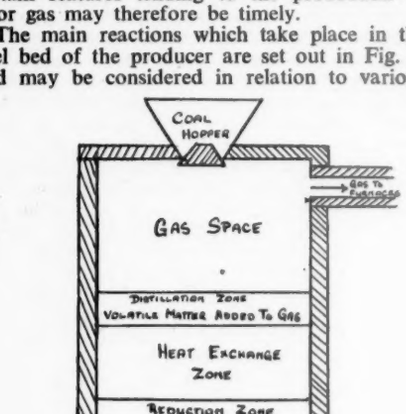


Fig. 1.—Gas Producer Reactions.

faults in producer operation. The diagram illustrates the reactions taking place at various levels in the fuel bed, the preliminary oxidation of carbon to carbon dioxide being effected in the first 4 to 6 in. of the fuel bed. All the oxygen in the incoming air is taken up in this first 6 in. of the bed, and subsequent reactions occurring higher in the producer are of a reducing nature, and are effected in the reduction zone. A further zone, which has been called the heat exchange zone, succeeds the reduction zone. Some reduction does take place in this heat exchange area, but the major part of the reducing reactions has occurred already in the previous zone below, and the primary effect achieved in the heat exchange area may be considered as an exchange of heat between the incoming fuel and the hot outgoing gases. Finally, in the top layer of the fuel bed, distillation takes place, and the gas made is enriched by any volatile matter which may be distilled from the fuel.

The most suitable gas for consumption in furnaces such as those used in the steel industry is considered to be one with as high a content of carbon monoxide as possible, and the amount of hydrogen is accordingly limited to 12 to 14 per cent. One of the ideas behind this is the fact that a carbon monoxide flame has about 2½ times the radiating power of a hydrogen flame of the same size. Other advantages in furnace operation are also gained by using gas high in carbon monoxide. For instance, rates of backfiring are much less with carbon monoxide-air mixtures than with the corresponding hydrogen-air mixtures. The producer should therefore be operated in a way which favours the production of carbon monoxide rather than hydrogen. Various factors influence the composition of the gas made—for example, clinker formation, gas channelling, excessive steam in the blast, improper thickness of the fuel bed, etc.

Cleaning Periods

One of the most evident causes of poor gas is the tendency for gas channelling as a result of chimney formation when parts of the fuel bed hang up in the producer. Around the edges of the producer, too, air leakage is likely to occur, since the fuel bed is particularly likely to work hollow at such points, and the resistance to gas flow is correspondingly lessened. The composition of the gas will be seriously affected by mixture of this "edge gas" with good gas if such leakage be allowed to continue unchecked. An illustration of the effect is provided by Table I, which shows the results obtained some years ago in an investigation on a 5-ft. producer, where ash was removed once daily.

Table I.—*Deterioration of Gas Composition consequent upon Prolonged Periods between Cleaning.*

Time after ash removal.	Gas present.	Gas composition. Per cent.	
		At producer wall.	20 in. from wall.
7 hrs. ..	CO_2	9.5	3.6
	CO	19.4	29.8
	H	11.3	6.0
8 hrs. ..	CO_2	13.8	4.3
	CO	12.4	27.3
	H	10.7	8.3
10 hrs. ..	CO_2	14.4	3.9
	CO	10.0	29.1
	H	4.8	11.0

The increase in the undesirable carbon dioxide by edge leakage is particularly marked; note the improvement, too, with respect to carbon monoxide in the gas within the body of the fuel bed. The formation of chimneys in the bed results in similar effects, since the blast then passes more rapidly through such channels; there is also very poor contact of gas with fuel, and a greatly reduced time of contact of blast and fuel, both factors causing a high content of carbon dioxide and consequently a poor gas. A further drawback of the producer working hollow is that chimneys frequently give rise to excessive clinkering caused by the localised high temperatures, because the proper reducing reactions and their attendant absorption of heat are not taking place.

Clinker formation aggravates the trouble in that lumps of clinker tend to impede the fall of the fuel bed; an obvious illustration is when clinker adheres to the wall of the producer. Tendencies for the producer to work hollow and produce poor gas are combated by poking through the fuel bed with a suitable bar passed through holes in the top of the producer, or by mechanically agitating the fuel bed. The amount of poking which is required depends, naturally, on particular conditions, such as the type of fuel used, type of producer, etc. For instance, small producers usually give more trouble in this respect than do large ones.

Poking and Chimney Formation

In general, a falling-off in gas quality may be suspected in the first place as due to the producer developing chimney formation and requiring poking. Some care is necessary in the poking operation. It is better practice to poke at short intervals, rather than to resort to such attention at longer intervals, but poking more vigorously. In poking, the operator should work over the whole of the bed, but giving particular attention to the neighbourhood of the walls. At the same time, care must be taken not to work too deep, since then ash or hot fuel may be lifted from lower down the fuel bed into the reduction zone. As a result increased amounts of ash will be exposed to the reducing gases and clinkering is very liable to occur under such conditions, as will be shown later.

Depth of Fuel Bed

There are various reasons why maintenance of the correct level of the fuel bed is important. If the fuel bed loses depth, there will be a reduced time of contact between the blast and the solid fuel, and since there will then be less reduction of the carbon dioxide, the quality of the gas made suffers. It is known by most producer operators that as complete decomposition as possible of the steam in the blast is highly desirable. A thin fuel bed also decomposes less steam than a thick bed, as shown by Table II.

These points are bound up with the fact that a thick fuel bed increases the temperature to which the gases are exposed, and this higher

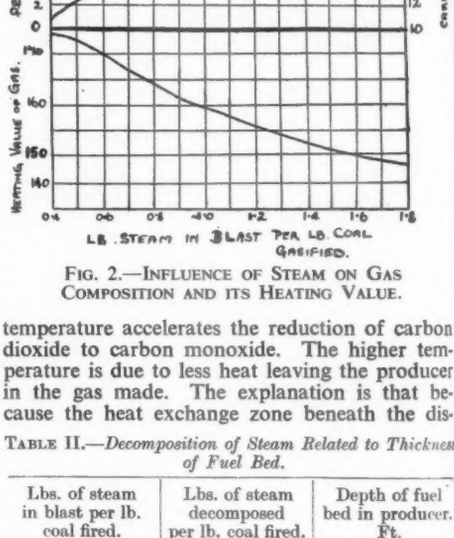

Per Cent Hydrogen
Carbon Dioxide
Carbon Monoxide
Per Cent Carbon Dioxide
Per Cent Carbon Monoxide or Hydrogen
Heating Value of Gas.
Lb. Steam in Blast per lb. Coal Gasified.

Fig. 2.—Influence of Steam on Gas Composition and its Heating Value.

temperature accelerates the reduction of carbon dioxide to carbon monoxide. The higher temperature is due to less heat leaving the producer in the gas made. The explanation is that because the heat exchange zone beneath the distillation zone (see Fig. 1) becomes thicker, consequently more sensible heat is taken from the outgoing gases, thus heating the incoming fuel to a higher temperature before it reaches the reduction zone of the producer. Actual measurements of temperature of reduction zones have shown increases of as much as 300 to 600 deg. F. A thick fuel bed thus aids in good-quality gas production due to the increased speed of reduction of carbon dioxide to

Table II.—*Decomposition of Steam Related to Thickness of Fuel Bed.*

Lbs. of steam in blast per lb. coal fired.	Lbs. of steam decomposed per lb. coal fired.	Depth of fuel bed in producer. Ft.
0.2	0.1	3.5
	0.13	5.0
	0.20	7.0
0.4	0.19	3.5
	0.23	5.0
	0.36	7.0
0.6	0.28	3.5
	0.33	5.0
	0.45	7.0
0.8	0.34	3.5
	0.41	5.0
	0.50	7.0

monoxide (resulting at higher temperatures), and also by the longer time of contact between gases and solid fuel.

A thick fuel bed, and accompanying increased operating temperature, is advantageous in other respects also. It has already been noted that for furnace consumption the gas made should preferably be high in carbon monoxide rather than hydrogen. It will be observed from Fig. 1 that it is possible for steam to react with carbon in the reduction zone in two ways, *viz.*:

(i) $C + H_2O \rightarrow CO + H_2$
Carbon Steam Carbon monoxide Hydrogen

(ii) $C + 2H_2O \rightarrow CO_2 + 2H_2$
Carbon Steam Carbon dioxide Hydrogen

In reaction (ii), therefore, not only is twice as much hydrogen produced, but there is in addition carbon dioxide rather than carbon monoxide. It follows that reaction (i) should be favoured if possible. This is accomplished by operating at a high temperature, or working with a thick fuel bed to favour high-temperature operation, since it has been found that at temperatures below about 1,650 deg. F. (900 deg. C.) the undesirable reaction (ii) is much quicker than reaction (i). Above this temperature, the rates of reaction are about equal, so that temperatures should be kept above this point. This has the added advantage, as noted above, that reduction of carbon dioxide to monoxide is also accelerated.

Disadvantages of Thick Fuel Bed

There are certain disadvantages with a thick fuel bed, chief among which is the increased tendency for chimney formation where gas channelling may take place. A compromise must be adopted to suit individual local conditions, such as the nature of the fuel used and the tendencies to form chimneys. The level of the bed should be measured at frequent in-

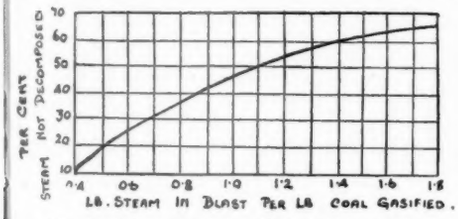


FIG. 3.—QUANTITY AND DECOMPOSITION OF STEAM.

tervals to ensure maintenance of the thickness found satisfactory for local conditions. This may be done by lowering a marked bar through the poker holes until the top of the fuel bed is reached, when a mark on the bar will correspond with the top of the poker hole when the fuel bed is at the correct level.

Naturally, the fuel bed must be kept at the same level over its full area, otherwise the thinner portions would impose less resistance to gas flow and the blast would pass through such portions more readily. Gas composition would deteriorate due to more rapid passage through the thin parts of the fuel bed. Charges of fuel must be spread evenly over the full area. Charging light and often is better than heavy and infrequent firing; the latter procedure involves a certain rise and fall in the height of the fuel bed, and a corresponding ill-effect on the composition of the gas made in accordance with the principles outlined above.

Steam Control

A brief examination of the effect of the amount of steam used in the blast may be useful, in order to illustrate how readily losses arise due to lack of care in this direction. Data from tests on a producer with a 7-ft. fuel bed are shown by Fig. 2. It will be observed that an increase in the amount of steam increases the proportion of hydrogen in the gas made, decreases the carbon monoxide, and increases the carbon dioxide content at the same time. The heating value of the gas also deteriorates as the steam consumption increases. These are undesirable conditions, as outlined earlier when discussing the quality of gas required for furnace heating.

It is a common fault to use too much steam, since conditions are then made easier for the operator. Table II has shown the effect of fuel bed depth on steam decomposition, and attention may be drawn to the fact that as the amount of steam used in the blast is increased, a smaller amount of steam is decomposed. This is true with all depths of fuel bed, and therefore indicates the need for using as little steam as possible in the blast. Theoretically, only about 0.35 to 0.40 lb. of steam per lb. of fuel should be used if the gas made is to have the maximum heating value and the most desirable composition for furnace consumption (see Fig. 2), but the character of the fuel used and other conditions have a modifying influence on this point.

The prime requisite is that the producer shall continue to make gas as long as works' requirements demand it, and continuity of operation is therefore more important than efficiency. Enough steam must therefore be used to prevent clinker trouble from becoming excessive; an increase in steam is effective in this direction, since it cools the fuel bed. According to ash characteristics, etc., therefore, it may be necessary to use 0.5 lb. or more of steam per lb. of fuel. This, of course, points to the value of using fuel with as high an ash fusion temperature as possible, since less steam can be used in the operation of the producer. Even so, many producers are operated with unnecessarily high proportions of steam in the blast.

Effect of Excessive Steam

The effect of excessive steam in the blast is further illustrated by Figs. 3 and 4. The proportion of steam undecomposed in a producer with a 7-ft. fuel bed, using various amounts of steam in the blast, is shown in Fig. 3. In Fig. 4 the undecomposed steam is related to the proportions of carbon monoxide and carbon dioxide. To obtain a gas high in carbon monoxide, or with a high ratio as in Fig. 4, it is evident from these two graphs that the steam consumption must be kept to the minimum to ensure the minimum of undecomposed steam. The proportion of steam in the blast is conveniently measured by taking the temperature of the blast; the air may be taken as saturated with water vapour, and therefore a given blast-steam saturation temperature will represent a definite proportion of steam. The temperature selected for controlling the blast on this basis will depend on the local factors, such as tendencies to clinker formation and the amount of steam therefore required to counteract the trouble.

Ash Fusibility

Some judgment of ash fusibility, and therefore tendencies for clinker formation, may be made from the appearance of the ash. One of the most common causes of low fusion temperature is the presence of a high proportion of iron oxide. Although this oxide does not itself fuse until near 1,535 deg. C., it can form silicates which are more readily fusible, and clinker formation at much lower temperatures is thus possible as a result of combination of the iron oxide and silica—both of which are present in the ash. The effect of iron oxide is illustrated by the examples given in Table III.

Some guidance may be obtained by noting the colour of the ash from the fuel, which will vary from a pure white or cream to a dark chocolate colour as the iron content increases. While other influences also affect the fusibility of an ash, it may be said that, as a general rule, the better of two coals will be that containing the lower iron content, assuming they are similar in other respects.

As reducing gases tend to increase ash fusibility, access of ash to the reduction zone should be minimised by careful procedure during poking. Here again the iron content of the ash is important, since it is known that iron oxides react with reducing gases such as carbon monoxide to form oxides which fuse at a lower

TABLE III.—*Effect of Iron Oxide on Fusion Temperature of Clinkers.*

Fusion temp. Deg. C.	SiO_2. Per cent.	Al_2O_3. Per cent.	FeO. Per cent.	CaO. Per cent.	MgO. Per cent.	Alkalis. Per cent.
1,150..	36.90	25.82	25.00	3.71	2.10	4.79
1,220..	40.40	29.34	15.21	4.61	1.96	7.23
1,330..	41.20	33.45	17.34	3.70	1.78	0.83
1,550..	51.80	38.25	5.64	0.45	0.74	1.71

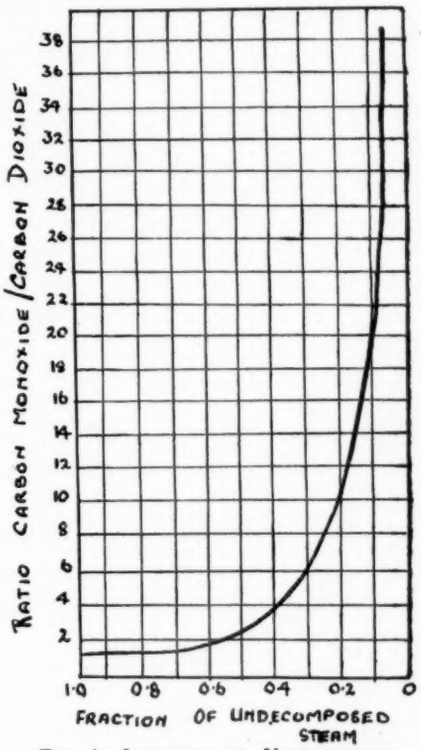


FIG. 4.—INFLUENCE OF UNDECOMPOSED STEAM ON $CO:CO_2$ RATIO.

temperature. Table IV illustrates the appreciable reduction in fusion temperature, and therefore increased clinkering troubles, which may arise as a result of such action.

TABLE IV.—*Influence of Atmosphere on Fusing Temperature of Clinker.*

Ash from	Fusion temperature in oxidising gases. Deg. F.	Fusion temperature in reducing gases. Deg. F.
Fuel A ..	2,490	2,395
,, B ..	2,640	2,610
,, C ..	2,640	2,500

Ash Removal Details

The removal of ash and clinker is necessary at intervals in accordance with local needs and conditions. The operation should be carried out regularly rather than at irregular intervals, since if the clinker level rises abnormally, the active fuel-bed depth will be reduced at times. The gas composition will then deteriorate as outlined in this article. Nevertheless, too much clinker must not be removed, since it serves to protect the grate from excessive heat, and therefore damage may result from removal of too much ash.

In some cases other dangers also arise from too thorough ash removal. For instance, with step-grate producers the upper bars of the grate must be sealed with ashes, or air will enter high

up in the fuel bed and poor gas will be made, since in effect this will be working with an unduly thin fuel bed. The depth of the ashes should be checked periodically by a poker test. Push a poker bar or other suitable rod straight through the fuel bed until it reaches the top of the grate. After ½ min. or so withdraw the poker and note the thickness of various zones. Tar and soot on the bar will mark the depth of the distillation zone; the red-hot portion will indicate the thickness of the hot reaction part of the fuel bed; then, knowing the distance from the top of the poker hole to the top of the fuel bed, the clinker level is easily figured. Alternatively, one can determine the length of the cold portion of the bar after removal, when this will correspond with the layer of ashes.

Factors in Control

Skilled operators are often able to judge how the producer is working from the appearance of the gas and the top of the fuel bed, but this needs considerable experience. Local requirements and conditions vary somewhat, but in general good practice yields gas containing under 5 per cent. carbon dioxide. If the gas made is high in carbon dioxide, however, one or more of the following faults may be suspected in the operation of the producer:—

(1) The fuel bed may be working hollow, giving poor-quality gas due to channelling of the blast and reduced time of contact of gas with fuel. Various causes of chimney formation may be examined, such as clinker formation impeding the fall of the fuel, insufficient poking of the producer, poking too vigorously and so lifting ashes into the reduction zone and causing clinkering, poor blast distribution causing high temperatures locally, etc., too high a rate of gasification, again causing excessive temperatures and clinker formation, etc.

(2) Excessive steam consumption in the blast, whereby the temperature of the bed is reduced and consequently too much undecomposed steam and unreduced carbon dioxide reach the gas made.

(3) The fuel bed may be too thin, due to it dropping sharply after an overdue removal of ash and clinker, or due to too high a clinker level, or collapse of the bed after an overdue poking, etc. The temperature is reduced under such circumstances, since the fuel receives less preheating in the upper layers of the fuel bed. Poor gas then results from the reduced time of gas contact and the smaller reduction of carbon dioxide.

(4) The rate of gasification may be too high, with increased temperatures developing clinker formation, and in turn leading to chimney formation and gas channelling.

(5) Air may be admitted over the fuel bed due to leakage on the producer, especially on the suction-type producer, and part of the carbon monoxide in the gas made may then be oxidised again to carbon dioxide. High gas temperatures, such as result from the use of too thin fuel beds, favour such re-conversion of the carbon monoxide.

The foregoing summarised faults will serve to emphasise that producer operating faults are often inter-related, and trouble in one direction is very liable to be aggravated by subsidiary effects caused by the primary fault. This points to the importance of careful attention to the major operating features as outlined in this article; such attention will then to a large extent also avoid these subsidiary associated difficulties.

(*Continued from col.* 3.)

pipe, the anticipated results were obtained, as was disclosed by sulphur prints. For certain steels, anti-piping compounds yield excellent results without the need of after-teeming; in some instances, there are definitely some disadvantages associated with the use of these powders.

Anti-piping Compounds

Dr. E. Gregory is presenting to the May Meeting of the Iron and Steel Institute a Paper entitled "Anti-piping Compounds and Their Influence on Major Segregation in Steel Ingots," which details work he has carried out on behalf of the Committee on the Heterogeneity of Steel Ingots. As compounds are sometimes used on the runners and risers of steel castings, we have extracted from the advance copy of Dr. Gregory's Paper portions which have a bearing on foundry practice.

The main object of using anti-piping compounds (Dr. Gregory states) has been to confine the primary pipe within the feeder head and so to increase the proportion of useful material. Matuscha (Journal, Iron and Steel Institute, 1938, No. I, 109 p.) has previously shown that

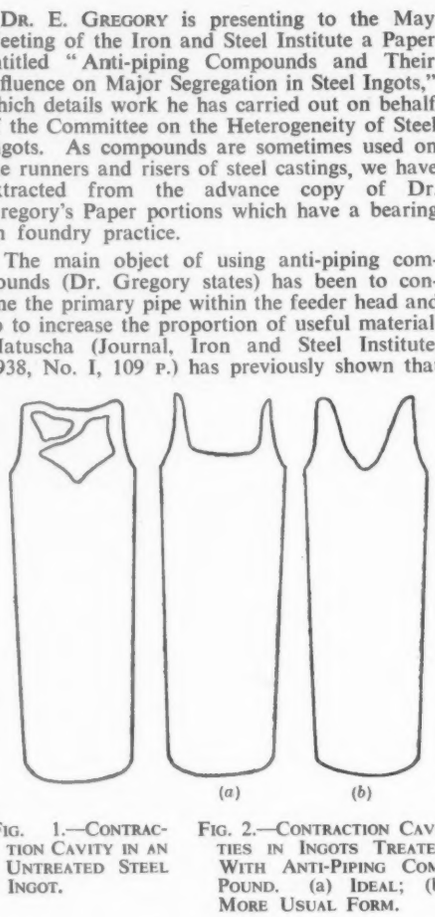


Fig. 1.—Contraction Cavity in an Untreated Steel Ingot.

Fig. 2.—Contraction Cavities in Ingots Treated With Anti-Piping Compound. (a) Ideal; (b) More Usual Form.

these compounds exert a marked effect on the shape and disposition of the pipe. The term "anti-piping" is somewhat unfortunate and to some extent is misleading, since, as already stated, pipe cannot be avoided in killed steels, as it is a natural consequence of the contraction that occurs during freezing. By means of these compounds, which are added in the form of powder to the surface of the molten metal in the feeder head immediately after casting, a reservoir of liquid steel is maintained in the head for a much more extended period. The result is the formation of an "open" pipe (*i.e.*, there is no bridging) in the feeder head, as represented in Fig. 2. The section indicated in Fig. 2 (*a*) represents the ideal case where the primary pipe consists essentially of a hollow shell. More often, however, the pipe takes the form of a hollow cone, as represented in Fig. 2 (*b*), in which case there is a greater possibility of the pipe extending into the body of the ingot.

The chemical compositions of the different proprietary anti-piping compounds differ considerably, as is evident from Table I.

Generally, therefore, these compounds consist essentially of mixtures of carbonaceous matter and irreducible oxides. When placed on the surface of the molten steel, the carbon and any other elements present slowly oxidise, thereby generating heat. The non-metallic matter in the powder remains as a residue which serves to insulate the molten metal beneath. It is this combination of heat-generating and heat-insulating properties which serves to delay the freezing of the metal in the head to such a marked extent. As is well known, the old practice of covering the molten metal with hot coke had a similar object in view. The difficulty with coke was that considerable carbon absorption took place, often accompanied by an exaggerated pipe. Earlier experiments also indicated that carbon was absorbed from the anti-piping powders by the molten metal in contact with it. With some low-carbon steels, which normally do not pipe to any marked extent, carbon absorption occurred to such an extent as to convert them, in so far as the freezing of the metal in the head was concerned, into "fully-piping" steels. Later, however, compound No. 5 was obtained and the amount of carbon pick-up was then reduced to negligible proportions, even though it is rich in carbon. This compound was exclusively employed in the experiments recorded in this Paper.

The primary object of this series of experiments was to determine the extent of the piped parts of blooms rolled from ingots cast (*a*) in the ordinary way, (*b*) treated with anti-piping compounds, and (*c*) treated with anti-piping compound and then "after-teemed." In the latter case, the feeder head was refilled with molten steel after several other ingots had been cast.

When using the anti-piping compound alone, a period of about 1 hr. elapsed between the casting of the ingot and the final freezing of the liquid metal surface in the head. During this period the liquid surface gradually sank to the extent of between 8 and 10 in. When both the powder and after-teeming were resorted to, the metal in the head remained molten for a period of between 1½ and 2 hrs.

The object of after-teeming, of course, was to replenish the supply of liquid in the head and still further delay its freezing so as to obtain a shorter and more squat pipe of the type indicated in Fig. 2 (*a*). Generally, in regard to

(*Continued at foot of col.* 1.)

Table I.—*Compositions of Proprietary Anti-Piping Compounds.*

Per cent.	1.	2.	3.	4.	5.
Al_2O_3	41.65	62.20	7.56	13.43	13.09
SiO_2	4.59	18.20	22.50	22.10	18.60
Fe_2O_3	2.52	2.60	3.50	6.10	1.71
CaO	2.09	3.50	—	0.80	—
MnO	0.17	—	0.44	—	0.09
MnO_2	—	—	—	—	—
Na_2O	4.24	—	0.72	—	0.636
K_2O	—	—			
CO_2	6.02	—	—	—	—
Mg	—	—	—	—	0.52
MgO	0.52	2.89	0.21	0.65	0.23
CuO	—	1.20	—	—	—
NaCl	—	2.18	—	—	—
KCl	—	0.36	—	—	—
Carbonaceous matter	21.33	6.80	59.56	48.17	60.45
Volatile matter	—	—	—	8.50	—
Loss on ignition	—	—	—	56.82	63.50

Malleable Cast Iron*

By H. G. HALL

What is malleable cast iron? Ten years ago it would have been said that malleable cast iron could be divided into two grades, whiteheart and blackheart. To-day, although these two types predominate, special malleable cast irons are being produced which can no longer be classified under either of these headings, and therefore a definition of malleable cast iron must be framed with care.

There is a definition suggested by the Malleable Committee of the B.C.I.R.A. which can hardly be improved:—"Malleable cast iron can be defined as any hard iron composition, cast into moulds, free from graphite in the unannealed or hard state, and in which, after heat-treatment, part or all of the carbide is transformed into temper carbon. If heat-treatment takes place in an oxidising atmosphere, the carbon is completely or partially removed by oxidation. The mechanical properties required of the finished product are governed by the method of heat-treatment."

Fundamentally, however, although there are several types of malleable cast iron, softening of the brittle cast iron is still controlled by (1) decarburisation—the basis of the production of whiteheart, or (2) graphitisation—the basis of the production of blackheart.

These two phenomena can best be understood by considering the changes taking place during the annealing of white cast iron.

Graphitisation

White cast iron consists at ordinary temperatures of pearlite and cementite and the changes taking place during graphitisation are as follow:—When white cast iron is heated above the A_1 critical point the pearlite changes to austenite which is capable of dissolving and retaining in solid solution certain definite amounts of cementite for definite temperatures. That is to say, austenite is capable of dissolving increasing amounts of cementite at increasing temperatures until for a definite temperature and time a saturation limit is reached and the structure will consist of saturated austenite and free cementite.

Therefore, assuming that a temperature of 900 deg. C. has been chosen as a maximum annealing temperature and that the temperature has been reached in the shortest practical time, the structure will consist of austenite and cementite, and as the temperature is maintained cementite will be dissolving in austenite. While this is going on, however, and before equilibrium (that is, the saturation limit of cementite in austenite at 900 deg. C.) is reached, the less soluble carbon or free graphite is being precipitated from the austenite. As annealing continues, more carbon is precipitated from the austenite as free graphite, the moduli of which rapidly increase in size. During the precipitation the austenite absorbs free cementite to maintain its saturation which is continually tending to be lowered by the precipitation of carbon.

This continued precipitation of graphite and corresponding absorption of cementite continues until there is no free cementite left. Equilibrium for the temperature chosen, in this case 900 deg. C., has been attained and the material consists entirely of saturated austenite and free graphite carbon. In theory, there is no point in holding at this temperature after equilibrium has been reached, and since austenite cannot hold so much carbon in solution at lower temperatures it will be necessary to work below 900 deg. C. in order to precipitate more free graphite. From 900 deg. C. the metal is allowed to cool slowly to the A_1 critical point, that is about 720 deg. C., graphitic carbon being progressively precipitated and the austenite becoming lower and lower in carbon contraction.

In fact, at and just below 720 deg. C., roughly 0.5 per cent. carbon remains in solution in the austenite, the rest of the carbon being present as graphite. If the temperature is dropped too rapidly at this stage, the 0.5 per cent. C is retained in the metal at ordinary temperatures as pearlite. In practice, therefore, cooling over the critical range should be slow so as to ensure complete graphitisation.

Summing up, graphitisation can be divided into two main stages: (1) Heating to and holding at a predetermined maximum temperature until all the free cementite has been dissolved and the structure consists of saturated austenite and free graphite, and (2) cooling to just below the critical temperature (roughly 720 deg. C.) and holding there if necessary, until the comparatively weak solution of austenite has been of the cementite to nodules of graphite.

By quenching the metal before the total disappearance of the cementite and examining under the microscope, it is possible to show up the slow change of the dissolved carbon of the cementite to nodulus of graphite.

A typical photomicrograph has previously been published[1] which showed the microstructure after annealing at 880 deg. C. for 2 hrs. and drastically quenching in water. The quenching was not drastic enough to prevent the austenite decomposing to martensite, but the structure is in other respects identical to that in which the material existed prior to quenching. It will there be seen that the austenite has absorbed much free cementite, although the original dendritic structure has not been completely broken down. A little graphite has already been precipitated from the austenite, and can be detected as small dark nodules in the decomposed austenitic background. A second micrograph[2] showed a further sample of the same iron water quenched after 7 hrs. at 880 deg. There is a conspicuous increase in the amount of temper carbon, the nodules of which have grown considerably. The ground mass of decomposed austenite was shown to have absorbed nearly all of the free cementite, residual traces of which were visible as a fine network around the crystal grains of decomposed austenite.

A third micrograph[3] showed the same iron which had been air cooled immediately when the temperature had dropped to 720 deg. C., and showed the pearlite resulting from insufficient time to have allowed complete dissolution of austenite at that temperature.

Normal Annealing Cycle

To emphasise the practical side of the previous data it may be advisable to consider them in the form of a graph of an ordinary annealing cycle, as is shown in Fig. 1, where *point* 1 indicates the austenite trying to dissolve sufficient cementite to reach its saturation limit for that temperature, and not succeeded because free graphite is being precipitated, thus weakening its solution; *point* 2 is the position where austenite has almost succeeded in dissolving all free cementite, and considerable graphite has been precipitated; *point* 3 is the place where no free cementite is left. The structure now consists of saturated austenite and nodules of temper carbon. In theory, there is no point in retaining at this temperature of any length of time, as no further graphite will be precipitated, but in practice it is rare to be able to say that it is certain that the whole oven has been at the required temperature for the whole period, and it is therefore advisable to extend this period as a safety factor; *point* 4 shows that the temperature is being allowed to drop, so that the dissolving power of austenite for carbon is lower and so to enable more graphite to precipitate, and finally *point* 5 serves to indicate that the second stage of graphitisation is usually obtained in practice by the use of well-insulated ovens, which prevent the temperature dropping rapidly and the time taken to drop over the critical range is slow enough to allow of the complete dissolution of the carbides just below the critical point. From this point cooling can be as rapid as is desired, but in practice it is not usual to open up the oven until the temperature has decreased to about 620 deg. C.

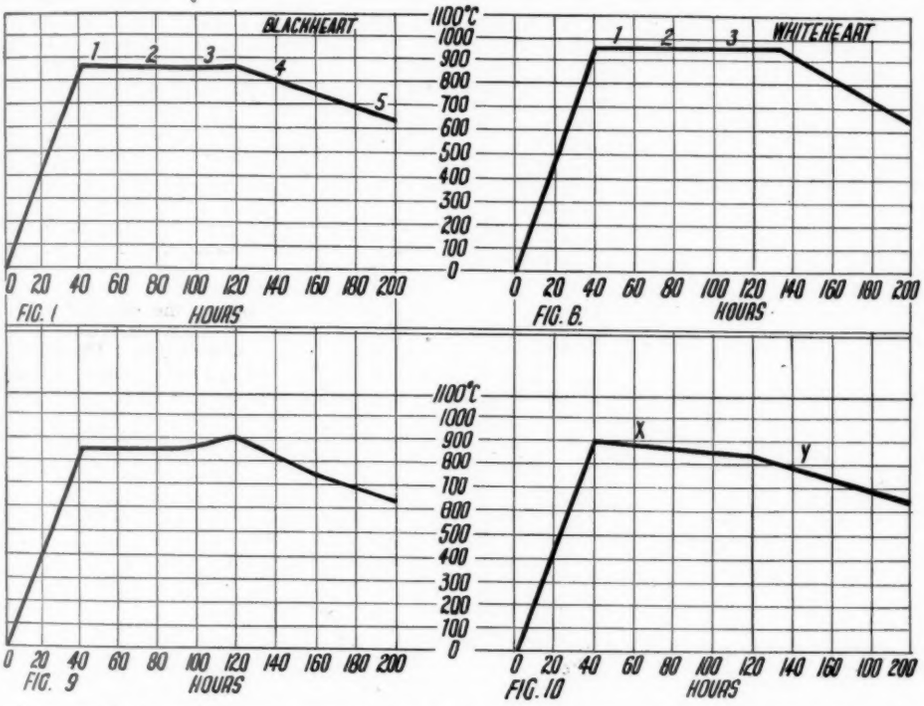


FIG. 1

FIG. 6.

FIG. 9

FIG. 10

* Paper read before the Birmingham Coventry and West Midlands Branch of the Institute of British Foundrymen.—Mr. A. Tipper, M.Sc., presiding.

As a matter of interest, the evolution of heat at the critical point will make itself seen on a continuous temperature record in the shape of a slight flattening of the curve or even in the form of a slight rise.

Quick Anneal Cycle

The annealing technique of those producing the so-called quick anneal could be considered at this stage. It must be obvious that the higher the initial maximum annealing temperature then the faster equilibrium will be attained, that is the time required to dissolve all free cementite completely. In fact, to illustrate this by the use of rough figures it is suggested that for a given

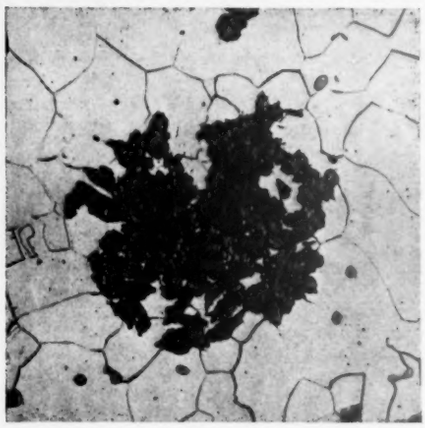


FIG. 2.—NORMAL FERRITE GRAPHITE STRUCTURE OF LOW CARBON MALLEABLE × 300. ETCHED 5 PER CENT. HNO_3 IN ALCOHOL.

iron, equilibrium or first stage graphitisation could be attained in

about 15 minutes at 1,050 deg. C.
or 6 hrs. at 1,000 deg. C.
or 24 hrs. at 900 deg. C.
or 50 hrs. at 860 deg. C.

The advocates of short-cycle annealing therefore use as high a temperature as they consider practicable and then insist that when they have attained equilibrium they may as well get on with second-stage graphitisation as quickly as possible. They suggest that the time used in cooling from the initial maximum temperature

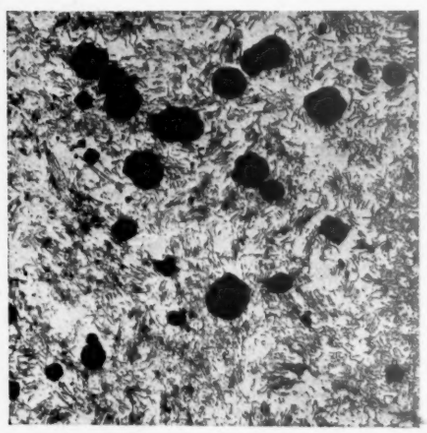


FIG. 4.—CENTRE OF WELL ANNEALED WHITEHEART × 150. ETCHED 4 PER CENT. PICRIC ACID.

to the critical stage does very little useful work (the author is to some extent in agreement with this) and therefore in effect it is practicable to quench from the maximum temperature to the critical stage and only hold there for sufficient time to complete graphitisation—a period in some cases less than 12 hrs. or a complete cycle of approximately 24 hrs.

There are, of course, other factors involved such as the use of border-line compositions, small ovens, etc., and it is suggested that although in theory the above suppositions are reasonable, there is no apparent safety factor. For a comparison of annealing times it is worthy of note that Schwartz has succeeded in completely graphitising a normal white cast iron at 725 to 710 deg. C. in 73 days.

Fig. 2 shows the normal ferrite graphite structure of a fairly low carbon blackheart iron. This structure is uniform from centre to edge in true blackheart, although there may be a slight rim of ferrite on some due to slight decarburisation.

Decarburisation

Decarburisation is the basis of the production of whiteheart malleable cast iron. It has sometimes been described as a mechanical process, compared with the physical changes taking place in blackheart production. This is hardly correct, as decarburisation is one of the most complex of metallurgical operations. Decarburisation takes place through the oxidation of carbon by oxygen and carbon dioxide gases surrounding the castings. An oxidising agent such as hematite ore—iron oxide—is generally used for this purpose. As space precludes a detailed examination of the various reaction of the gases present during decarburisation, it is suggested that those interested study the classic diagram of Dr. Schenk showing the iron-carbon-oxygen equilibria in relation to temperature. Various chemical equations are given, some of which are reversible at different temperatures and pressures.

The gases surrounding the castings, rich in carbon monoxide produced by the combustion of the carbon, are regenerated by the oxidising media—usually hematite ore—which gives up part of its oxygen according to the main equilibrium reaction:—$Fe_2O_4 + CO \rightleftharpoons 3\ FeO + CO_2$.

Briefly then, the castings, packed in hematite ore, are raised to a predetermined temperature, say 960 deg. C., as rapidly as is practicable, and here again as in the case of iron suitable for graphitisation, the structure consists of austenite attempting to reach its saturation limit by dissolving free cementite and at the same time precipitating carbon as free graphite. The oxidising action of the gases takes place continuously from the surface to the centre of the castings so long as the carbon content of the metal tends to equalise itself by the migration of the dissolved carbon of the portions rich in that element towards the impoverished surface layers, *i.e.*, by the migration of the rich solid solution of austenite in the centre towards the poor solid solution of austenite at the edge.

Simply stated, the carbides from the solid solution of austenite at the centre are continuously being removed by oxidation. This reaction proceeds quickly so long as there is any free cementite left.

The austenite is continuously trying to reach its saturation limit for 960 deg. C., so that as the solution weakens at the edge the austenite at the centre dissolves more cementite and migrates towards the edge in an attempt to replace its saturation limit. The decarburisation from edge to centre proceeds much more slowly when there is no free cementite left and the austenite has to start dissolving the already precipitated graphite in order to maintain its saturation. Apart from castings of thin section, however, decarburisation is practically never complete.

After cooling down, the centre of a section usually contains a small quantity of temper carbon, plus the decomposition product of the remaining austenite solution—namely, pearlite. It will be evident therefore that the predominating factor controlling successful decarburisation is mainly the speed at which carbides migrate from the centre towards the edge. It is obvious that this speed will be increased by the use of higher maximum annealing temperatures. Moreover, according to Schenk's equilibria diagrams, the speed of the regeneration of the carbon monoxide and the reaction of the packing medium are accentuated at higher temperatures.

Unfortunately, the facts do not help each other sufficiently; in other words, the danger is that the speed of decarburisation is so great that migration of carbon from centre to edge cannot keep pace with it and surface oxidation of the castings occurs, resulting in iron oxide penetration. Leroyer states and practical experience confirms that the speed of migration

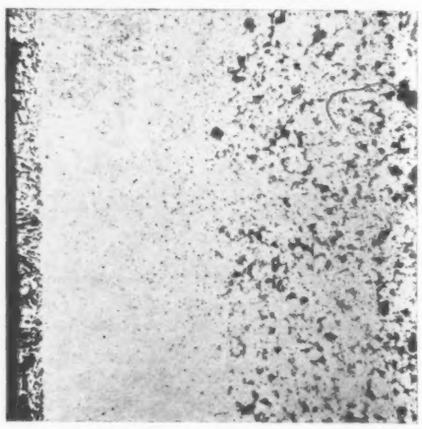


FIG. 3.—EDGE OF WELL ANNEALED WHITEHEART × 150. ETCHED 4 PER CENT. PICRIC ACID.

can be helped by lowering the silicon content and generally of all the elements which enter into solution with the gamma iron. The migration of the solid solution after all the cementite has been used up is far more difficult and it is therefore necessary to reduce any tendency of the iron to graphitise to a minimum. In addition to the lowering of the silicon content, the presence of an excess of sulphur over that required to form manganese sulphide, however small the excess may be, undoubtedly favours the retention of carbon as carbide and not as graphite. The use of sulphur in this respect

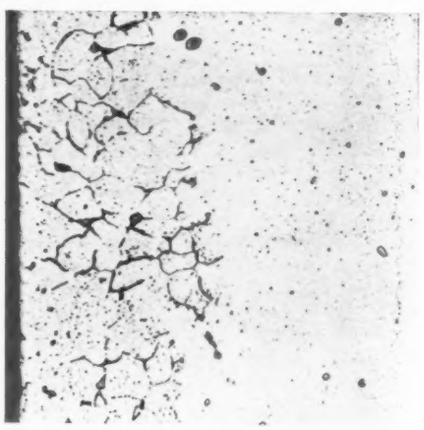


FIG. 5.—ILLUSTRATES A CASE OF OXIDE PENETRATION × 300. ETCHED 4 PER CENT. PICRIC ACID.

therefore constitutes the main compositional difference between blackheart and whiteheart hard cast irons.

Thin castings will decarburise more quickly than thick castings, as owing to the comparative chilling action during casting the cementite goes into solution more quickly at the maximum annealing temperature.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

A word of warning must be given on the use of too low a silicon content, because during cooling there is a risk that the pro-eutectoid cementite will separate out in the centre of the castings, rendering them extremely brittle. It is, of course, the excess of sulphur which prevents the decomposition of the weak solution of austenite remaining at the critical stage into graphite and ferrite, the solid solution changing almost completely into pearlite.

Fig. 3 shows the edge of a well-annealed whiteheart casting; the extreme edge consists of completely decarburised iron, there being a progressive increase in carbon towards the centre. Fig. 4 shows the centre of the same section and it will be seen that the main background consists of pearlite with a little ferrite, and the temperature carbon is in the well-rounded form usually

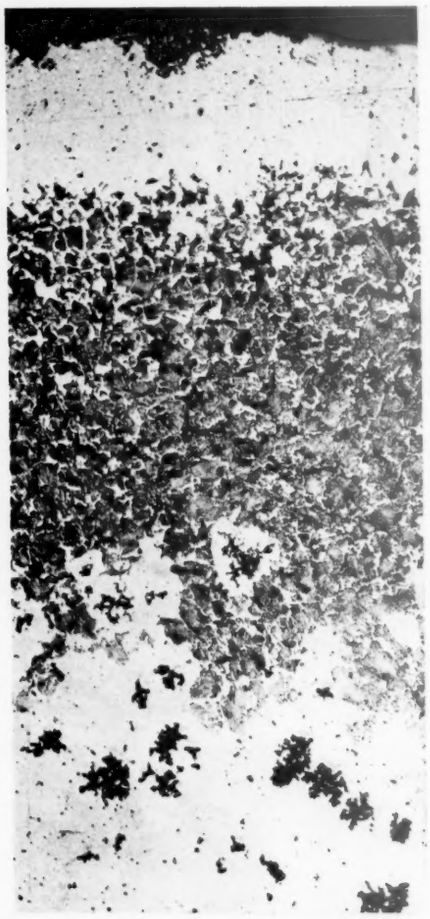


Fig. 7.—An Example of the "Picture-Frame" Phenomenon × 100. Etched 4 per cent. Picric Acid in Alcohol.

associated with irons having a slight excess of sulphur. Fig. 5 illustrates the oxide penetration at the edge indicating excessive decarburisation.

Referring to the decarburisation data given in Fig. 6 showing the forms of a normal time-temperature curve:—

Point 1 indicates the location where austenite is trying to dissolve sufficient cementite to reach its saturation limit and again graphite being precipitated although not nearly so fast as in the case of the more easily graphitised iron suitable for blackheart work. On the surface the austenite is being impoverished due to oxidation.

Point 2 shows the place where not much free cementite is left in the centre, as a concentration gradient has been set up between the surface and centre of the castings. The austenite at the centre is absorbing the remains of the cementite and attempting to diffuse or migrate towards the edge in order to enrich the poor solution of austenite remaining there.

Point 3 is the position where decarburisation is still proceeding but as there is no free cementite left, the austenite is compelled slowly to dissolve the already precipitated graphite in order to replace its concentration in the now very weak solution at the surface.

This stage is critical because of the comparative slowness of migration of solution from centre to edge and it is easy to set up zoning, that is decarburisation overbalances migration and the result is at worst the oxidation of surface iron resulting in oxide penetration and eventually in peeling, when an oxidised layer of metal is formed which breaks away from the surface of the casting. At best the result is, from edge to centre, a deep layer of ferrite, a sharply defined layer of pearlite and then the normal ferrite-pearlite-graphite core.

Potentialities of CO-CO_2 for Decarburisation

From the above it must be obvious that the mechanical side of the operation of decarburisation is somewhat clumsy and must if progress is to be registered be superseded. Referring

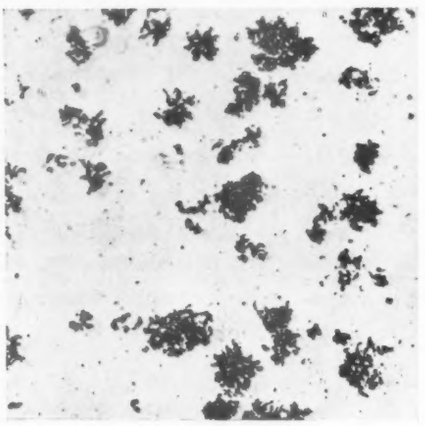


Fig. 14.—Centre of the Sample Shown in Fig. 13. × 150.

again to Point 3 of Fig. 6, if at this juncture, or perhaps even earlier, the oxidising atmosphere could be changed to a neutral one for a sufficient length of time, the carbon-rich area at the centre would have time to diffuse towards the edge until the whole area was of uniform carbon concentration. This would permit rapid decarburisation again to take place. This process could be repeated, and there are grounds for stating that the sectional limitation which now applies in the production of whiteheart castings could partially be overcome.

It is suggested with some diffidence that a gas mixture of carbon monoxide and carbon dioxide could be used as an oxidising agent, the gases being applied in such proportions that the carbon is oxidised but not the iron, and in support of this it is germane to recall that in a recent Paper[1] by Kalling and Rennerfelt it is stated that these gases are being used to decarburise granulated pig-iron, the product being used for the manufacture of high-quality steel. These authors point out, however, that increased silicon contents slow up the rate of decarburisation, and they suggest as a reason that an oxide film is formed which becomes progressively less permeable to the oxidising gases.

Further support in favour of de-carburising by the use of CO-CO_2 mixtures is given by Lissener and O'Kahl in their Paper "Recent Studies on the Graphitisation of White Cast Iron." Research on the above lines might well mark a decided step forward in the production of malleable cast iron.

"Picture Framing"

Decarburisation and graphitisation have been dealt with at some length, and these two phenomena have been associated with whiteheart and blackheart respectively. In practice, however, there is nearly always some degree of decarburisation in the production of blackheart. It may take place as a result of the packing (if any be used) being insufficiently inert, or as a result of an oxidising atmosphere in the oven itself. The result of this partial oxidation may be what is unhappily designated "picture-frame malleable." A personal view is that the term "picture-frame malleable" is misleading, as it implies malleable which is difficult to machine, with high tensile and low elongation values. These factors apply only if the product is accidental and has taken place during the attempted production of true blackheart. Malleable cast irons are often deliberately pro-

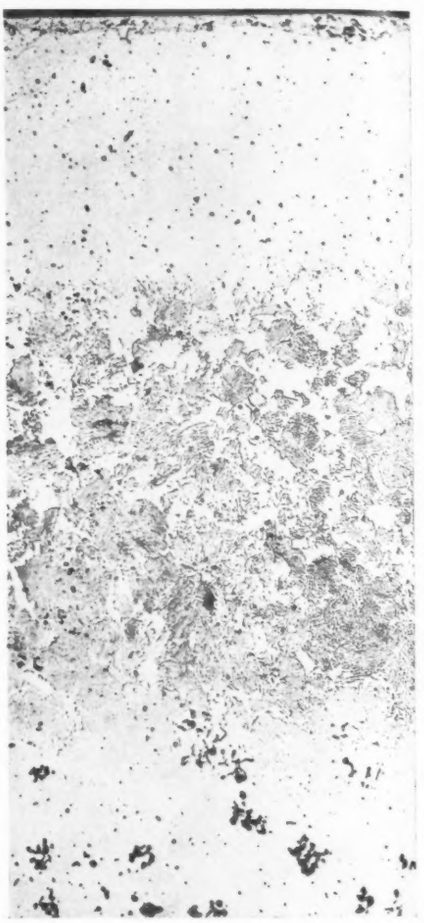


Fig. 13.—Edge of High Carbon Iron. Annealed Under Decarburising and Graphitising Conditions. × 150.

duced having a so-called "picture-frame" fracture. Such irons must never be regarded with contempt.

Consider briefly the type of "picture-frame" malleable which does give trouble in machining, from the annealing side only. A typical example is shown in Fig. 7.

The main difference from true blackheart consists of a heavy pearlitic rim, the core being usually quite normal. The hardness of such an iron is shown diagrammatically in Fig. 8. It is a personal opinion that such irons are produced by pure annealing technique, as the same hard iron properly treated usually results in true blackheart. For instance, a time-temperature curve of the type shown in Fig. 9 would be liable to produce a "picture-frame" malleable. The rise of temperature occurs at a point where there is no free cementite to even out any con-

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My Guineas!
In Future
My Pigiss

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P.S.

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centration radient which might be set up by surface oxidation. A further illustration may be drawn from a realisation that the same trouble would occur if the oven atmosphere at point 3 in Fig. 1 became heavily oxidising. On the other hand, an oxidising atmosphere at point 1 (Fig. 6) would rarely be detrimental as diffusion would cancel out oxidation.

The last few hours at maximum temperature are usually a safety factor to cover temperature and compositional variations. From decarburisation and graphitisation data, therefore, it would appear that a curve of the type shown in Fig. 10 is a practical way of utilising those facts and producing true blackheart. Safety is ensured through a number of hours at gradually decreasing temperatures—temperatures, however, at which the austenite is still giving up part of its carbon as graphite.

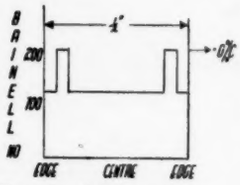


Fig. 8.—Brinell Hardness of "Picture-Frame" Iron.

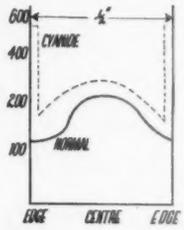


Fig. 11.—Brinell Hardness of Whiteheart.

Summarising this type of "picture-frame" malleable, it is suggested that it is almost impossible to graphitise decarburised sections where the carbon content has been reduced to below 0.9 per cent. Pearlite is the stable form of carbon in these conditions, and although the reactions necessary for decarburisation are reversible and can result in recarburising, it is not thought that this is the reason for these heavy pearlitic rims. Incidentally, Howe succeeded in completely graphitising a 0.3 per cent. carbon steel—but only in the presence of over 3 per cent. silicon.

Indentation Hardness of Malleable

Brinell hardnesses of whiteheart and blackheart cast irons are shown graphically in Figs. 11 and 12, which indicate that it is possible to visualise the comparative machining speeds. Therefore, from a machining point of view, there is some justification for demanding blackheart in preference to whiteheart unless the latter is limited to thin-section castings only. There are, however, many intricate castings of thick and thin sections, and if whiteheart is chosen the machining of the thick sections must inevitably be somewhat slower than that of blackheart. If blackheart be chosen then certain foundry difficulties may present themselves. Usually the carbon content of whiteheart hard iron is higher than that of blackheart hard iron. The resulting extra fluidity is of considerable value in running intricate thin and thick sectioned castings. The use of a hard iron of suitable high carbon but of suitable composition for graphitising and therefore for making blackheart might suggest itself. This is of course possible, but under existing B.S. Specifications the minimum tensile strength demanded for whiteheart or blackheart is 20 tons per sq. in. The use of a truly high carbon content giving iron of sufficient fluidity to produce good sound castings of intricate thin and thick sections, usually involves that however well controlled the annealing technique, the tensile strength is often below 20 tons per sq. in. on a 0.564-in. bar although elongations of up to 12 and 14 per cent. can still be obtained. The bend value, too, is comparatively low—in the region of 70 deg. on the standard bar. It is possible, however, to utilise the advantages of a high-carbon content without materially affecting the normal physical properties of blackheart castings by combining the graphitisation and decarburisation processes.

Fig. 13 shows the edge of a high-carbon hard iron, annealed under decarburising and graphitising conditions. The decarburised edge of ferrite reveals a very slight band of scattered pearlite, and towards the centre, the normal ferrite-temper carbon structure.

In Fig. 14 the centre of the same section is shown; it consists of normal temper carbon and ferrite, the temper carbon being rather larger than normal low-carbon blackheart. The tensile strength of the material was 24 tons per sq. in. associated with 14 per cent. elongation and the 180-deg. bend on the normal bar, whilst hammering and deforming tests seemed quite normal. In this way a product can be obtained giving 22 to 26 tons per sq. in., 10 to 14 per cent. elongation, and 180-deg. bend. There

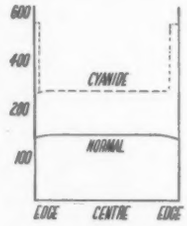


Fig. 12.—Brinell Hardness of Blackheart.

appears to be a great future for malleable iron of this type.

The advantages of a high initial carbon content are self evident. In America, pipe fittings are invariably made of cupola blackheart because soundness is of paramount importance. Smaller feeders can be used resulting in a saving in iron and fuel, and nowadays this fact is of some importance. One eminent engineer, when discussing whiteheart and blackheart, stated: "The future malleable cast iron for engineering purposes will be a semi or intermediate product possessing the best combination of mechanical properties of well-made material of both types."

REFERENCES

[1] "Malleable Cast Iron" by G. R. Shotton and H. G. Hall, Foundry Trade Journal, May 29th, 1930, p. 403, Fig. 14.
[2] *Loc. cit.* (Fig. 15).
[3] *Loc. cit.* (Fig. 16).
[4] Foundry Trade Journal, vol. 61. (1939), p. 231 *et seq.*

(*To be continued.*)

Melting Operations in the Non-Ferrous Foundry

(*Continued from page* 219.)

At an altitude of 90,000 ft., water would boil at 10 deg. C. A similar position arises in the vacuum melting of alloys.

In connection with removal of gas from alloys, it is possible that there are other metals which will act in a similar way to zinc by lowering the vapour pressure or the boiling point, and an investigation into this matter might lead to some very interesting results.

Whatever the reason, the fact remains that alloys in this group are outstanding in that they are practically unaffected by variations in melting conditions so far as gas absorption is concerned. In other words, it does not matter whether one employs melting furnaces giving reducing, neutral or oxidising atmospheres. It is important to note, however, that the evolution of zinc vapour should take place in order to obtain satisfactory results. Care must therefore be taken to ensure adequate superheating temperatures and, of course, there must be enough zinc present for free evolution. This latter point is particularly mentioned as it is not yet certain that alloys containing, say, less than 15 per cent. zinc are free from gas absorption during melting. However, it can be accepted that brasses containing over 15 per cent. zinc, including manganese bronze, etc., are relatively fool-proof so far as melting technique is concerned.

In view of brasses being immune to hydrogen pick-up, it must also be evident that the initial gas content of the virgin metals employed for making up the alloy is of little moment. For example, cathode copper, which contains appreciable quantities of hydrogen, can be readily used for brass production although special precautions would have to be taken if such were used for the manufacture of sand-cast gunmetal or bronze castings.

Genders and Bailey also draw attention to another very interesting point which clears up a past misconception. Most foundrymen hold the opinion that in the melting of brass, oxidising conditions lead to greatest metal loss. This appears incorrect as the above investigators have proved that reducing conditions lead to highest zinc loss. The experimental method utilised consisted in heating small quantities of alloy in a tube furnace through which either air, nitrogen or hydrogen could be passed in a regular stream. The furnace atmosphere obtained from the passage of these gases duplicates oxidising, neutral or reducing conditions obtained in practice. The losses in weight of the metal samples after treatment were as are shown in Table II.

Pure brass in the molten state, when exposed to air or oxidising conditions, is rapidly covered by a surface film of oxide which has the effect of reducing the evolution of zinc. The thinner film formed under nearly neutral conditions permits a greater zinc loss to take place, but this is still much less than that obtained when the formation of the oxide film is entirely prevented, as arises in the presence of hydrogen. Furthermore, it is interesting to observe that these conditions do not apply to molten brass containing even small amounts of phosphorus. This is due to the fact that phosphorus removes the oxide film from the surface of the brass and high zinc losses arise with any type of melting atmosphere. This property of phosphorus in reducing metallic oxides should be particularly noted as its action in this direction is of considerable importance in connection with alloys such as gunmetal and bronzes, to be discussed later. Oxides containing aluminium are one of the few oxides that phosphorus will not reduce and it has therefore no effect on the high tensile brasses containing aluminium. The affinity of aluminium for oxygen at melting temperatures is so much higher than that of phosphorus that a phosphorus-aluminium brass behaves as if phosphorus were absent.

To summarise the position in connection with the melting of alloys in the brass group the following main points emerge:—

(1) Melting atmosphere does not seem to play an important part in the production of the usual copper-zinc alloys so far as gas absorption is concerned providing zinc fume is evolved.

(2) The raw material basis of the metal charge has little effect.

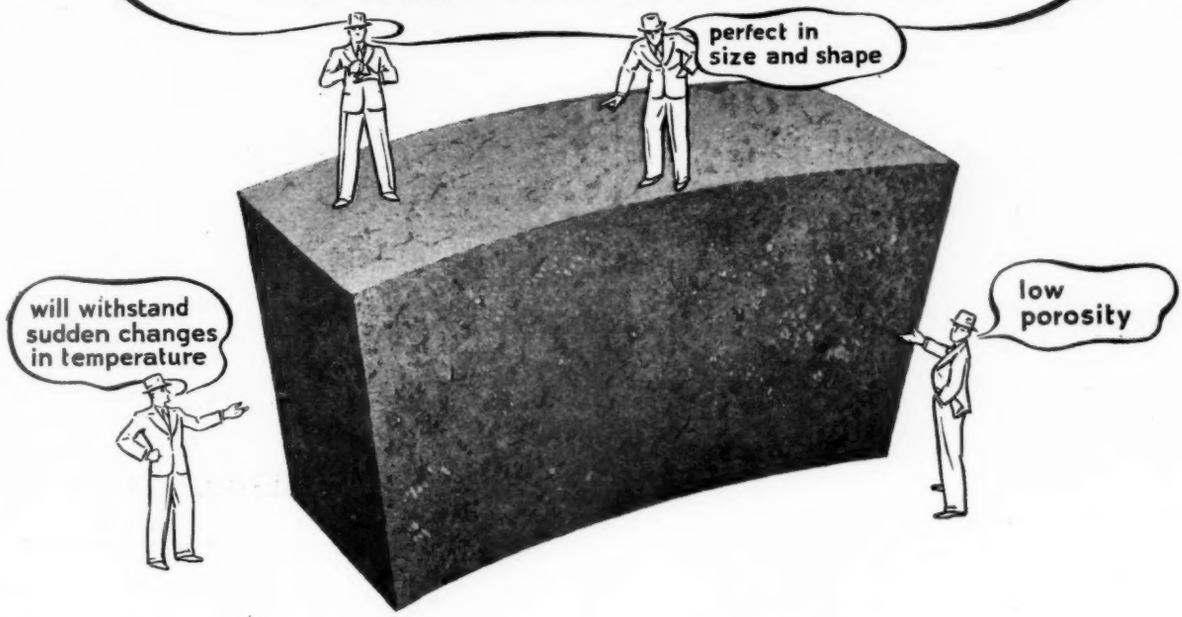
(3) Lowest metal losses, particularly of zinc, are obtained with oxidising furnace atmospheres, but this does not apply when even a trace of phosphorus is present in the alloy, except in brasses containing aluminium.

(*To be continued.*)

Catalogue Received

Fluxes. An eight-page, well-illustrated pamphlet has been received from Multiple Acting Flux, Limited, of 11, Oxford Terrace, Gateshead-on-Tyne, which details the results which have been given by a series of fluxes used in connection with various non-ferrous alloys. It is available to our readers on writing to Gateshead.

Reliability - is certainly the word to describe these bricks



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The Week's News in Brief

Trade Talk

"SHEFFIELD" is now registered in the United States as a community trade mark in the name of the Cutlers' Company.

A WARTIME TRADE AGREEMENT was initialed last week on behalf of the British and Danish Governments. The object of the agreement is to facilitate the flow of trade as far as is possible under present conditions.

S. A. COMMENTRY-FOURCHAMBAULT ET DECAZEVILLE in the eight months to August 31, 1939, made a net profit of 14,636,195 fcs., against 10,767,595 fcs. in 1937/38. Dividends of 52.50 fcs., against 40 fcs. per ordinary share and of 40 fcs., against 27.50 fcs. per preference share, have been declared.

IN RECOGNITION of his rescue of a 13-year-old boy from drowning in the Forth & Clyde Canal at Kirkintilloch on December 17, Mr. Hugh Cole, a steelfoundry worker, of John Street, Kirkintilloch, has been presented with the parchment of the Royal Humane Society together with £5 from the local town council.

WORKERS ARE to take their holidays as usual this year in the absence of unforeseen circumstances. The National Joint Advisory Council, representing employers and trade unions, in recording this decision, express the view that every opportunity should be used to spread over the incidence of holidays as far as local industrial circumstances permit.

THE NET PROFIT for the final quarter of 1939 of the International Nickel Company of Canada, Limited, was $10,262,660, equal to 67 cents per common share, after preferred dividend. This compares with $8,115,095, or 53 cents per share, in the corresponding 1938 quarter, and $8,811,368, or 57 cents, in the preceding three months of 1939. The total net profit for 1939 was $36,847,466, an increase of $4,447,996.

SEVEN Coatbridge families share awards totalling over £3,000 given by Lord Patrick in the Court of Session, Edinburgh. They lived in a tenement in Allan Street which was set on fire following the collapse of a 120-ton chimney on August 23, 1938, at Woodside Foundry, belonging to the Scottish Iron & Steel Company, Limited. The total sums sued for amounted to £12,500 and awards total £3,327 10s.

SHIP-REPAIRING and even a certain amount of shipbuilding is to be carried on in South Africa under the auspices of the British Admiralty. During the last war more than £2,000,000 was expended in South Africa for Admiralty account in the form of ship repairs and allied work. The Union is the most highly industrialised section of the Continent and ships serving the greater part of the African coast have repair facilities at Capetown, Simonstown and Durban. The establishment of the Pretoria steelworks and many big modern engineering plants has equipped the Union for ship-repairing and reconstruction tasks far beyond its capacity 25 years ago, though the virtual reconstruction of many badly damaged ships was even then carried out.

THE MINISTRY OF SUPPLY announces that the Area Advisory Committee at Glasgow has been inaugurated, and held its first meeting on March 20. The members are:—Nominated by Engineering Employers' Federation: Mr. John B. Lang (John Lang & Sons, Limited, Johnstone); Mr. Alex. S. MacLellan (Alex. Stephen & Sons, Limited, Linthouse); Mr. A. E. Mascall (Wm. Beardmore & Company, Limited, Glasgow); Mr. J. B. Mavor (Mavor & Coulson, Limited, Glasgow); Mr. T. Cleland Gourlay (A. F. Craig & Company, Limited, Paisley); Mr. W. H. Birks (Babcock & Wilcox, Limited, Renfrew); Mr. W. H. Howden (James Howden & Company, Limited, Glasgow); Mr. James Douglas Latta (Scottish Stamping & Engineering Company, Limited, Ayr); Mr. E. Bruce Ball (Glenfield & Kennedy, Limited, Kilmarnock); and Mr. D. Higgins (North-West Engineering Trades Employers' Association, Glasgow). Amongst those nominated by the T.U.C. is Mr. J. M'Bain (National Union of Foundry Workers).

HIGH DUTY ALLOYS, LIMITED, of Slough and Redditch, are putting down a works at Distington, in the North of England, which when in full production will employ 1,200 workers. After a luncheon given by the Cumberland Development Council, Col. W. C. Devereux, managing director of the company, stated that it was proposed to train local labour and plant was being installed and teachers brought to the local County Technical School at a cost of £11,500 in the first year. This plant and equipment, worth many thousands of pounds, woud be handed over to the school by trustee gifts and would be there for all time. Col. Devereux stated that as soon as people realised that it was weight and not bulk that mattered the use of aluminium would increase rapidly. It was the extensive use of aluminium instead of copper that was keeping Germany going at the present time. She was using aluminium instead of copper piping. She was also using aluminium in architecture and transport as well as in the magnetic mine, while battleships were overcoming the question of weight in the same way.

Personal

MR. H. J. BECK, foundry foreman, Ley's Malleable Castings Company, Limited, Derby, has been the recipient of a long-service certificate and £5. The presentation was made by Sir Gordon Ley, the governing director.

PROF. W. M. THORNTON, Emeritus Professor of Electrical Engineering at King's College, Newcastle-upon-Tyne, has accepted an invitation from the North-East Coast Institution of Engineers and Shipbuilders to deliver the 1940 Andrew Laing Lecture. His subject will be "Fundamentals of Power Transmission with reference to the Electrical Theory of Matter."

PROF. GILBERT COOK, D.Sc., Regius Professor of Civil Engineering and Mechanics in Glasgow University, has been admitted to Fellowship of the Royal Society. He is well known for researches into a wide variety of engineering problems, and particularly for original investigations into the stress-strain relations of metals when passing from the elastic to the plastic state under systems of combined stresses. Previously he was Professor of Mechanical Engineering and head of the department of Civil and Mechanical Engineering in London University, King's College.

Will

BAINES, CHARLES, director, W. N. Baines & Company, Limited, engineers and ironfounders £23,004

New Companies

(From the Registar compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

H. H. Green & Russell (1940), Limited, Temple Street, Wolverhampton—Capital £2,500. Ironfounders, etc.

A. C. G. (Non-Ferrous) Founders, Limited, rear of 761, London Road, Hounslow—Capital £500. Directors: F. Naylor and S. Moody.

Hermansen Furnaces, Limited, 66½, Corporation Street, Birmingham—Capital £3,000. Builders and erectors of industrial furnaces, particularly for non-ferrous metals.

Weldall & Assembly, Limited, Spring Hill, Birmingham—Capital £6,000. Ironfounders, steelworkers, welders, etc. Directors: A. S. Hollings, W. E. Ballard, E. H. M. White and R. C. Lightbourne.

Contracts Open

Ashington, April 1—Cast-iron goods for 12 months from April 1, for the Urban District Council. The Surveyor, Town Hall, Ashington, Northumberland.

London, E.C., April 1—Iron and steel, bolts and nuts, screws, files, tubes, iron, brass, gunmetal and other castings, etc., for 12 months from June 1, for the Metropolitan Water Board. The Chief Engineer (Room 171), Offices of the Board, New River Head, 173, Rosebery Avenue, London, E.C.1.

Shrewsbury, March 26—Cast-iron goods, tools, furnace slag, etc., for 12 months from April 1, for the Salop County Council. Mr. Wm. H. Butler, county surveyor, County Buildings, Shrewsbury.

Obituary

MR. ARTHUR WILLIAMS MILLS has died in Birmingham at the age of 83. Mr. Mills was a native of Birmingham, and was for thirty years in business as a rolling mill proprietor in Gray Street, Garrison Lane. He sold his works as a going concern to Richard Jones, Limited, in 1916, since when he had lived in retirement. Mr. Mills was well known in metal circles in Birmingham.

MR. THOMAS WINNING, retired foreman patternmaker, died suddenly at his home, 18, Craigie Road, Riccarton, Kilmarnock, last week, at the age of 79. He served his time as patternmaker with Glenfield & Kennedy, Limited, and when he retired in 1928 he had served the company for over 51 years, including many years as foreman of the patternmaking shop. His brother, Martin, was former works manager of the firm, and is now in retirement. His son, William, is foreman in the engineering shop.

WE REGRET to announce the death of Mr. F. W. Bridges, which took place at his home at Woodford, Essex, last Wednesday at the age of 71. Whilst his major activity was the publishing of business newspapers, he was probably best known to our readers as the organiser of a series of Foundry Trade Exhibitions. His son, Mr. Kenneth W. Bridges, as honorary secretary of the Foundry Trades' Equipment and Supplies Association since its inception in 1925, is perhaps better known to the younger generation. However, during the actual holding of the exhibitions, everybody met Mr. Bridges, senior, and quickly learnt to appreciate his organising ability, his generous hospitality, and his invariably cheerful personality.

Reports and Dividends

C. Akrill & Company, Limited—Dividend for 1939 of 15 per cent. on the ordinary shares.

Vickers, Limited—Final dividend on the ordinary stock of 6 per cent., making 10 per cent. for the year 1939.

Thos. Firth & John Brown, Limited—Final ordinary dividend of 11½ per cent., tax free, making 17½ per cent.

Range Boilers, Limited—Net profit for 1939, £13,997; brought in, £2,573; ordinary dividend of 20 per cent.; carried forward, £2,868.

Delta Metal Company, Limited—Net profit for 1939, after tax, £99,004; brought in, £19,628; dividend of 12½ per cent. and a bonus of 15 per cent., both tax free; written off plant, etc., £15,000; carried forward, £20,632.

General Refractories, Limited—Net profit attributable to company, £50,084, after following group provisions: Taxation, £50,025; A.R.P. and consolidation expenses, £8,502; depreciation, £41,764; dividend of 5 per cent.; carried forward, £54,936.

British Thomson-Houston Company, Limited—Profit for 1939, before providing for taxation, £1,038,046; brought in, £182,829; taxation, £410,000; depreciation, £287,087; to general reserve, £100,000; ordinary dividend of 7 per cent.; carried forward, £192,058.

British Insulated Cables, Limited—Profit for 1939, £783,224; brought in, £486,558; depreciation and directors' remuneration, £175,643; final dividend on the ordinary stock of 10 per cent., plus a cash bonus of 5 per cent., making 20 per cent.; to war contingencies reserve account, £100,000; to reserve, £13,334; carried forward, £488,305.

Shanks & Company, Limited—Net profit for 1939, after providing for taxation, bad and doubtful debts, depreciation and other charges, £52,387; preference dividend, £4,664; interim dividend of 2½ per cent. on the ordinary shares, £7,250; brought in, £42,886; to war contingency fund, £10,000; ordinary final dividend of 6 per cent. (making 8½ per cent.), £17,400; carried forward, £55,959.

Forthcoming Event

APRIL 4.

Iron and Steel Institute and Swansea Technical College Metallurgical Society:—"The Influence of the Steel-Base Composition on the Rate of Formation of Hydrogen-Swells in Canned Fruit Tinplate Containers—Part I." by Dr. T. P. Hoar, T. N. Morris and W. B. Adam; and "Practice in the Manufacture of Rimming Steel" (Ninth Heterogeneity Report), presented by J. Mitchell, at the Royal Metal Exchange, Fisher Street, Swansea, at 6 p.m.

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Raw Material Markets

Easter this year has not brought the customary lull in business in the iron and steel trade. The pressure of demand is such that makers will continue to operate plant wherever possible, while few consumers will feel disposed to close their works to deliveries of raw material. The blast furnaces, of course, will be working as usual over Easter; but steel plant will, in most instances, be closed for a day or two, when the opportunity will be taken to make any necessary repairs. Generally, the iron and steel makers are content to deal with orders in hand without seeking fresh business. The appetite of the steel furnaces for pig-iron is seemingly insatiable, and during recent months additional furnaces have been turned over to the manufacture of basic iron. There is no actual shortage of foundry grades; but supplies are necessarily directed primarily into those channels where the iron is to be used for munitions and other work of national importance. The surplus remaining is distributed very fairly by the Control, and the foundry trade as a whole is able to carry out a good deal of ordinary domestic work and to operate, though on a restricted scale, for the export trade. There are suggestions that a further advance in prices is contemplated. So far, war increases have gone to a central fund to meet the heavy costs entailed in importing raw material from abroad, and no portion of the increases has gone to the actual makers. Internal costs, however, are rising; wages have advanced, coal, coke and scrap prices are higher, and it is claimed that some part of the increase must, sooner or later, be passed on to the consumer.

Pig-Iron

MIDDLESBROUGH—The light-castings foundries in the Middlesbrough area, as in other parts of the country, are still indifferently employed, and the fact that the manufacture of Cleveland iron has been temporarily suspended has not, so far, been a matter of great moment to the foundries in this area. Orders for foundry numbers have been diverted to the Midlands, and satisfactory supplies have been forthcoming, although occasionally users have had to accept grades of iron other than those to which they have been accustomed. Stocks of Cleveland iron in this area are now of slender proportions. Nevertheless, it seems to be unlikely that the manufacture of this grade will be resumed in the near future. The position as regards foundry iron generally should be easier immediately after the Easter holiday, for while the blast furnaces will have been working as usual, consuming trades will have been idle for at least a day or two.

The demand for East Coast hematite pig-iron is being satisfactorily met, though substantial withdrawals from stocks have had to be made. Producers are not keen to enter into forward commitments, as, without further additions to order-books, business in hand will absorb the bulk of the output for some time to come. It may be necessary shortly to increase output.

LANCASHIRE—Quiet conditions are still reported in the light-castings trade in this area, and the demand for pig-iron from this direction is correspondingly light. Activity in the heavy electrical and machine-tool branches has been maintained on a good scale, and there is keen demand for low-phosphorus pig-iron and hematite to meet the needs of these trades. Jobbing foundries in Lancashire are now better employed, though some of them could take on much more work than they are at present receiving. All supplies of West Coast hematite coming into the district are readily absorbed under licence.

MIDLANDS—There is little difficulty in securing supplies of high-phosphorus pig-iron, though deliveries are, of course, regulated by the Control. There are no reports of consumers of this class of iron being inconvenienced by lack of supplies. The reason, of course, is that this grade of iron is used chiefly by the foundries making builders' castings, and, owing to the suspension of activity in the building trade, these foundries are poorly employed. They have not yet been able to secure sufficient work of other kinds to make up for the loss of their most important market, although there is hope that their services will be utilised by the Government to a greater extent in the near future. The demand for low-phosphorus grades and for hematite for the engineering and allied trades continues to expand; and although consumers are securing their requirements, supplies have to be carefully regulated and stocks, where they exist at all, are meagre.

SCOTLAND—Engineering foundries continue to be well employed; but there is no improvement in the position of the light foundries centred in the Falkirk area. Supplies are sufficient to cover requirements; but no surplus is going into stock. The light-castings foundries continue to take their supplies mainly from the Midlands of England at the fixed prices of 109s. 9d. f.o.t. Falkirk and 112s. 9d. f.o.t. Glasgow, less 5s. rebate in each case. The output of basic pig-iron has recently been increased.

Coke

Movements in coke prices are now linked with those of pig-iron, and no further change has taken place. Durham furnace coke is quoted for delivery in various parts of the country on the basis of 31s. 8d. f.o.t. at ovens, and foundry coke at 37s., also at ovens. For delivery in the Birmingham area, Durham foundry coke is quoted at 53s., and the makers are willing to book contracts up to the end of the half year, though not at a firm figure, orders being accepted on the basis of the price ruling at the date of despatch. Supplies are coming through regularly, and in some instances consumers are able to accumulate a little stock.

Steel

Re-rollers are in a better position, at the moment, as regards supplies of steel semis than they have been for several months. The improved position is due to the arrival of substantial supplies of billets and sheet bars from abroad. This satisfactory position will enable the re-rolling mills to give much-needed help to the steelworks, whose light mills have been in arrears with orders. A fuller production of bars, strip, etc., should now be possible. The finished steel mills are achieving maximum outputs; but every ton of joists, heavy sections and plates produced is readily absorbed. The sheet mills are still working to capacity.

Scrap

The recent advance in scrap prices certainly seems to have brought about a better flow of material to the scrap yards and thence to the consuming plants, and it is hoped that this movement will be continued. With steel output at its present level, scrap must necessarily be brought in from abroad. This was the normal procedure in peacetime; but in the present emergency it is essential that imports should be kept as low as possible, and every extra ton procured from home sources is a help. All steel scrap arising from home sources is readily absorbed, and the foundries and wrought-iron works can take care of all the supplies of iron scrap which become available.

Metals

Free trading on the London Metal Exchange is still confined to tin, and, in these circumstances, somewhat dull markets must result. Tin has been a fairly active market; but it has been affected by the proximity of the Easter holiday, and rather less business has been done as compared with recent weeks. The statistical position will be watched with interest following the decision to reduce outputs; but no fear is held of maintaining ample supplies to meet national needs. The consumption of copper continues to be on a very large scale; but, here again, thanks to the unselfish co-operation of the Empire producers, satisfaction of the country's needs is assured. The demand for spelter of all grades continues to be heavy, and a large tonnage of lead is also going into consumption, despite the inactivity in the building trade.

Metal Exchange prices for tin this week have been as follow:—

Cash—Thursday, £252 10s. to £252 15s.; Friday, £251 15s. to £252 5s.; Monday, £248 to £248 10s.; Tuesday, £247 15s. to £248.

Three Months—Thursday, £251 15s. to £252; Friday, £250 to £250 5s.; Monday, £246 to £246 10s.; Tuesday, £246 5s. to £246 10s.

Stress-Relieved Cast Irons

(*Continued from page* 218.)

Referring again to Fig. 4, it should be pointed out that the stress-relieving process slightly affects the hardness of the iron, because the heating precipitates a certain quantity of graphite and ferrite—both soft constituents, replacing a corresponding amount of cementite, a hard constituent. An iron with a Brinell hardness of 250 as-cast would after the stress-relieving process be about 180. Some machine-tool specifications, however, demand a hardness higher than 200 Brinell—sometimes 220—the test being taken on the bearing surfaces. Thus there is bound to be some opposition on account of the stress-relief treatment clause, when there is hardness to consider.

This difficulty is, in the author's opinion, easy to overcome. It is necessary to note that the castings in question are submitted to relatively deep machining, which eliminates a large quantity of surface material and thereby diminishes the effect of internal stresses. The reheating process can, due to this fact, be of a milder type and experience has shown that by not exceeding 525 to 550 deg. C., the hardness is conserved, the graphitisation then being at a minimum. Because of its definite character, stress-relief heat-treatment is obviously preferable to weathering, as the latter is complicated by climatic variations.

Not only should castings for precision machine tools be so treated but also liners and other Diesel engine components, and turbine cases. Again, where variable temperatures are encountered, as is the case with domestic saucepans, metal melting pans, chemical ware, ingot moulds, etc., this treatment can be usefully employed.

Catalogue Received

Emergency Material—The Stanton Ironworks Company, Limited, near Nottingham, has just issued its first wartime publication, entitled "Stanton Products in Wartime." A well-written foreword contrasts the danger from air raids during the last war and at the present time, associating with this the infinitely better measures for remedying any damage so caused. The object of this booklet has been to describe how Stanton products are helpful to the engineer faced with the dual problem of maintaining public services and the protection of his colleagues during air raids. After pointing out that centrifugally cast-iron pipe is a much better shock-resisting material than its predecessor, attention is drawn to the speed with which repairs can be carried out using the newer types of joints and by the rapid replacement of broken pipes by others of smaller diameter. In the pages dealing with air-raid shelters, systems employing both concrete and cast iron are described and illustrated.

Aluminium Works at Resolven

In the House of Commons, Sir W. Jenkins asked the Minister of Supply what progress was being made with the aluminium works at Resolven. Mr. Burgin said he was informed that progress was being made with the plant and that it was hoped to commence production towards the end of the year. Consideration was being given to further proposals for additional production in South Wales.

Iscor Developments

Dr. J. H. van der Bijl, chairman of the South African Iron & Steel Industrial Corporation, has stated that the present works at Pretoria, whose steel-ingot capacity is 340,000 tons yearly, are to be expanded to a capacity of 440,000 ingot tons yearly. New works are also to be established whose capacity will eventually equal that of the present works. Although the Pretoria works now supply a quarter of South Africa's steel needs, steel demand in the Union is expanding so rapidly that even with the extensions planned Iscor is not expected to supply much more than this proportion.